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POPULAR ASTRONOMY

PLAINLY WORDED AND LARGELY UNTECHNICAL IN LANGUAGE. AMPLY ILLUSTRATED.

ISSUED MONTHLY EXCEPT JULY AND AUGUST
ANNUAL VOLUME (10 NUMBERS.)

VOL. XV.

1907.

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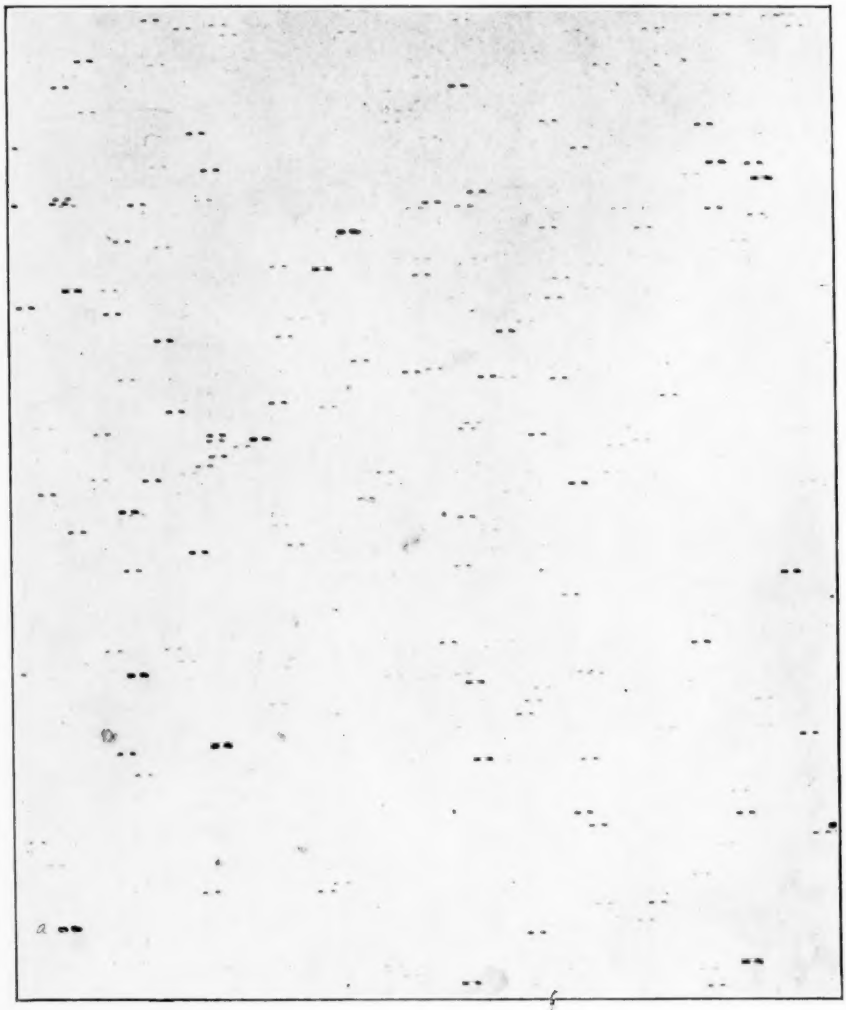
OFFICE OF PUBLICATION:
GOODSELL OBSERVATORY OF CARLETON COLLEGE,
NORTHFIELD, MINNESOTA,
U. S. A.

+405

PLATE I.



NEW COMET DISCOVERED BY REV. JOEL H. METCALF, TAUNTON.

[Discovered from this photograph taken Nov. 14, 1906.]

Popular Astronomy.

Vol. XV No. 1. JANUARY, 1907. Whole No. 141

PROGRESS OF ASTRONOMY IN 1906.

E. WALTER MAUNDER.

FOR POPULAR ASTRONOMY.

The Sun. The state of the Sun's surface during the year ending October 31, 1906, points to the sunspot maximum being already passed; a marked falling off in both the numbers and areas of sunspots having been noticed since the beginning of 1906. Whilst 1905 was remarkable for the number of giant groups very easily visible to the naked eye, these have been rare during 1906, the most striking outburst being one that commenced on the visible hemisphere on July 27, and rapidly increased in size until by the end of the month it had attained an area of twelve hundred millionths of the Sun's hemisphere. The tendency has been rather for spots of moderate size to form in long processions parallel to the solar equator; a very remarkable instance of such a procession was observed in November 1905, and another not quite so pronounced in March 1906. October 1906 was a very quiet month; indeed the Sun was then entirely free from spots on no fewer than seven days. A similar falling off has been remarked with respect to the faculae, but it has been less pronounced than with the spots; the mean area of which for 1906 was about three-fourths of that for 1905. On the whole the maximum seems to have fallen about the end of 1905 for faculae and prominences, whilst the maximum for spots should probably be placed at least six months earlier. Yet a caution must be observed in deciding thus soon as to the precise date of the turn of the cycle, for sunspots generally continue to be very active for fully four years at maximum during which they exhibit several strongly marked fluctuations, before the period of decline definitely sets in. It is therefore even yet somewhat premature to conclude that no further marked recrudescence of activity will be witnessed in the course of the present cycle.

A new determination of the stellar magnitude of the Sun has been made by Professor Ceraski, who employed the planet Venus as an intermediary for the comparison between the light of the Sun, and of Polaris, Procyon and Sirius; comparing Venus with the Sun by day, and with the stars named by night. He found

the Sun's light one million times greater than Polaris x 290550; Procyon x 77630; or Sirius x 17045. The weighted mean of these three determinations gives the stellar magnitude of the Sun as —26.59, or as Professor Ceraski prefers to express it, as 26.59 *super magnitude*.

The calorific radiation of the Sun has been determined afresh by MM. Millochau and Féry from observations made at three different levels; viz. Meudon altitude 150 metres, Chaumonix, 1030 m., and Mt. Blanc, 4810 m. The maximum observed temperature at the last named station was 5590° absolute; giving, when roughly corrected for the atmospheric absorption, 5610° absolute, for the final result.

A research which promises important results has been initiated by Professor Hansky at Poulkowa in the photographic registration of the forms and movements of the granulations of the solar surface. Professor Hansky found that he was unable to recognize the forms of the granulations in successive photographs taken by M. Janssen at Meudon, but by taking photographs at intervals of from fifteen to thirty seconds on a scale of nearly two feet to the solar diameter it was found possible to trace the changes and movements to which the granulations were subject. After an interval of a minute, the same granulation was usually recognized with difficulty. The dimensions and rates of motion of the granulations varied within wide limits but their mean diameter was about 1″.9, and mean speed about 21 km., per second.

The Sunspot Cycle. The uncertainty as to our present position in the sunspot cycle, lends great interest to an attempt which Professor A. Schuster has made to examine the precise nature of the sunspot periodicity. The method which he has employed in the analysis of the sunspot numbers of the last 150 years, is an application of Fourier's theorem, and he claims to have discovered in addition to the well-known cycle of 11.125 years, a number of minor periodicities, the integration of which in their varying intensities, produces the irregularities of the cycle actually observed. These minor periods are 4.78, 8.32; 9.25; 13.5; and 13.75 years; and Professor Schuster points out the most strongly marked of these are, like the 11.125 period, simple sub-multiples of 33.375; whilst two-fifths of that period gives very nearly the value of the shorter 13-year period. The multiplicity of these periods, their near approach to commensurability, and the fact that they undergo suppression for considerable intervals of time, throw grave suspicion upon their reality, which it is to be hoped

that the promised publication of the details of his investigation, will enable Professor Schuster to remove. In the meantime, Professor Schuster regards the relation of these periods to 33.375 years, which is nearly the revolution period of the Leonid Meteors, as a strong confirmation of his view that the secret of the sunspot variation is to be found in meteoric influence. Indeed in the *Observatory* for May 1906, he claims to trace the "third of a century" cycle by means of Chinese sunspot observations as far back as A.D. 188, and draws attention to a coincidence, noted by Professor Turner, namely that the Leonids only entered the system in A.D. 126. He considers it possible that a meteoric stream might pick up some of the negative ions which had previously been projected outwards by the Sun, and if it did so, might at perihelion, supposing that it was then within a few solar diameters of the Sun, affect the luminosity and shape of the corona, the variation of the spot phenomena following as a secondary effect of the coronal disturbance. The occasional disappearance of a period might be accounted for if it is supposed that radioactive matter is irregularly scattered through space, and that the meteor streams sometimes traverse a barren, and sometimes a rich region. It will be seen that in its present form, at any rate, Professor Schuster's theory is confined to the mere suggestion of vague possibilities, hardly consistent with what we know of any meteor stream; certainly not with the Leonids which have their perihelion passage at about one hundred solar diameters from the Sun.

Sunspot Spectra. A number of valuable papers on this subject have appeared during the year, chiefly in the *Astrophysical Journal.* Besides the actual catalogues of "widened lines", and of "Maunder's bands" observed, the two chief questions debated are: "What is the cause of the darkness of sunspots?" and "Are sunspot spectra represented in stellar spectra?" On the first of these two questions Messrs. Hale and Adams do not accept Evershed's suggested defence of Maunder's view that the darkness of a sunspot is in part due to diminished radiation; for Evershed supposed that the maximum of intensity of the sunspot spectrum might be displaced into the extreme ultra-violet; whilst they found it was displaced to the infra-red. They also reject Fitzgerald's suggestion brought forward by Dr. W. E. Wilson, that the great convection currents which must exist within such a gaseous layer as that seen in a sunspot, would limit effective radiation to quite a shallow stratum. They therefore conclude "that the darkness of sunspots may be sufficiently well accounted

for by absorption alone." Messrs. Hale and Adams are also quite unable to support Lockyer's view that at the period of sunspot maximum the lines due to known elements are replaced by unknown lines. Their observations showed that but a little more than a quarter of widened lines were "unknown," and many of these were of extreme faintness, whilst more than one-sixth of the lines were due to iron. Nor do their results support Fowler's conclusion that lines in the spot are strengthened in proportion to their intensities in the Sun in the case of elements like titanium represented by comparatively faint lines.

The other question under discussion has also produced a difference of opinion. Dr. W. M. Mitchell failed to find much correspondence between the spectra of sunspots and those of the fourth type stars. Hale and Adams on the other hand found the typical sunspot lines strongly affected in the spectra of Arcturus and of Alpha Orionis (second and third type stars), the lines being least affected in the Sun and most affected in Alpha Orionis, suggesting that the temperature of the last named star is the lowest.

Cloud Spheres and Photospheres. These discussions may receive illumination from a suggestive paper by Mr. A. W. Clayden, read before the Royal Astronomical Society. In this he points out that the result of suitably diminishing the mass of a planet may be to produce exactly the same effect upon any cloud-sphere by which it is surrounded, as would be brought about by increasing its temperature. A hot planet of large mass might present exactly the same features as a cooler and smaller one, and a determination of the temperature of the outer surface of the cloud sphere would be no measure whatever of the temperature of the solid planet beneath. A strictly analogous result holds good in the case of the photospheres of stars. The determination of the temperature of a photosphere is no guide to the temperature of the star center. Neither is the position of the photosphere much help. If the ratio of temperature to pressure in two stars be identical, their spectra will be identical, so that a large hot star may show exactly the same spectrum as a smaller and cooler one.

The Moon. The publication of the Ninth part of the great Photographic Atlas of the Moon by MM. Loewy and Puiseux, has given the authors an opportunity for discussing several theories with respect to the lunar surfacing. The seas and craters of the Moon cannot have been caused by swarms of meteors circulating round the Sun, and encountering the Earth and its satellite, nor by the ejects from terrestrial volcanoes, nor by the

capture of a primitive satellite ring once revolving round the Earth. But their studies have convinced MM. Loewy and Puiseux, as their chief predecessors in this field has been convinced, that the preponderating part in the formation of the lunar seas and craters must be assigned to volcanic forces acting from within the Moon itself, and not to any external origin. In the *British Astronomical Association Journal*, Mr. H. G. Tomkins has argued that the brightness of the radiating streaks is due to saltpetre, and other saline products working upward to the surface, adducing a phenomenon of the kind which he has not observed in the Panjab. Professor W. H. Pickering doubts whether the phenomenon observed by Mr. Tomkins is more than a local effect, as he has not observed it on the salt prairies in the Western States.

Mars. During the past year, the only observer of Mars who has published his observations has been Mr. Percival Lowell of Flagstaff, Arizona. In the *Monthly Notices* for December 1905, he gives as the most probable position of the pole of the Martian equator: R. A. 317°.5, and Declination 54°.5, Epoch 1905. Tilt of Martian equator to Martian ecliptic, 23° 59′. This value has been adopted in the *Nautical Almanac* beginning with the volume for 1909. Mr. Lowell has also issued in a fine volume, his observations of Mars during the oppositions of 1894, 1896, 1898, 1901, and 1903. These oppositions were all previous to Mr. Lowell's successful photography of the canals of Mars, and the work has naturally fallen into two great divisions:—the polar caps, and the surface outside them. Mr. Lowell points out that the details of one Martian year are not the exact counterpart of those of another, except in the one respect of position. If a canal or spot is seen, it is seen *in situ*, but it may not be seen at all. In the opposition of 1896, he drew attention to the important fact that the Gihon and Hiddekel were detected as doubles, important in that one of each pair left its own bay of the Sabaeus Sinus, and as the two bays of the Sabaeus Sinus have been universally accepted as facts, this at once negatives the conclusion that the doubling, in these cases at least, was optical. In the opposition of 1900, he remarks that the duplex canals surrounded the oases which they passed, one component passing round the oases on one side, and the second component on the other; the oases themselves were not doubled as they should have been, were the phenomenon merely diploptic.

The Asteroids. Mr. Joel Metcalf in the *Astrophysical Journal* for May, proposes a novel method for the photographic discovery of asteroids. The method of Professor Max Wolf is to take a

long-exposure photograph of the region to be examined, and then search the plate for trails made by the moving planets. As the asteroids, when in opposition, move on an average 34″ per hour, it is possible that they may be too faint to produce any impression on the plate. Now objects of any degree of faintness can be photographed if the exposure be sufficiently prolonged, and Mr. Metcalf proposes to give the photograph a motion of about 34″ an hour in a given direction, thus following an asteroid with a considerable degree of accuracy. The small planets would present disks that are nearly round, whilst the brighter stars would give short trails. In the July number of the *Astrophysical Journal*, Dr. H. N. Russell gives the results in an investigation on the light variations of asteroids and satellites. He concludes if a variable asteroid has been observed at a series of oppositions in all parts of its orbit, that we can determine whether its light curves can be accounted for by rotation alone, and if so whether the asteroid (a) has an absorbing atmosphere, (b) is not of a convex form, or (c) has a spotted surface. He also shows that it is not possible to determine the shape of an asteroid; if any continuous convex curve is possible, all such forms are possible.

The Minor Planet TG. Three new minor planets were discovered by Dr. Max Wolf on a photograph taken on February 22. Two of these were remarkable for their rates of retrogradation; TF moving unusually quickly, and therefore being of small mean distance, TG moving very slowly and so being of great mean distance. The latter planet has, on further observation, proved of extreme interest. Eros, discovered eight years ago, is the nearest of all the asteroids, coming at its perihelion well inside the orbit of Mars; its distance being only 1.1 units. TG, on the contrary, is the most remote, and breaks the bounds usually assigned to the asteroid family on the other side, for at aphelion it passes beyond the orbit of Jupiter. Nor is this all. Not only are its mean distance and its period almost precisely the same as those of Jupiter, but its distance in longitude from Jupiter is nearly 60°, so that the Sun, Jupiter and TG very nearly occupy the points of an equilateral triangle. Lagrange had shown that this was a possible case of the Problem of Three Bodies, and Dr. Charlier has further proved that the system might be stable even if the triangle were not accurately equilateral to start with.

Jupiter. Major Molesworth has published his observations of Jupiter for the year 1904-5 in the January number of the *Monthly Notices*. When his observations ended in June, the great south

tropical dark area was practically in conjunction with the Red Spot bay. In the passage of this dark area by the Red Spot, the same phenomenon seems to have occurred as in 1902, June, namely as the preceding end of the area reached the following shoulder, a dark wisp formed across the south tropical zone at the preceding shoulder, and moved down the zone at the normal speed of the dark area. As soon as the following end reached the following shoulder, the dark area became complete on the other side of the bay, and moved off at its normal speed down the zone. The dark area seems to have passed neither *over* nor *under* the bay but *round* it by way of the South Tropical Belt completely skirting the oval of the bay without encroaching on it in any way. The dark area has a peculiar effect on the rotation period of the dark "wave crests" in the south edge of the South Equatorial Belt, and the intervening white spots. Before the formation of the dark area these markings had a period practically identical with that of the Red Spot; but since the formation of it, in May 1901, their period has been very variable, retarded as it approached them, accelerated after its passage and returning to their normal rate with increasing distance from it. The great South Dark Area has had an effect on the rotation period of the Red Spot itself Mr. Denning shows in the *Observatory* for September that from March 24 to May 4, the Great Red Spot and the Hollow in the South Equatorial Belt moved as nearly conformably as possible to Ephemerides based on a rotation period of $9^{d}\ 55^{m}\ 40.6^{s}$, but in June the Dark Area was in conjunction with the Red Spot, and in the following three months the spot lost 16° or $26^{m}\ 29^{s}$ relatively to the zero meridian, the rotation being $9^{d}\ 55^{m}\ 33.8^{s}$, a much more rapid rotation than has been previously observed.

Jupiter's VIth and VIIth Satellites. The two small new satellites of Jupiter have been observed, not only where they were discovered at the Observatory on Mt. Hamilton, but they have also been photographed at Greenwich. At the latter place, images were secured with the record short exposure of seventeen minutes. Dr. F. S. Ross has published a new orbit of Jupiter VII, giving it a period of 259 days which is eight days longer than that of VI. But the orbits of the two satellites have very similar eccentricities, inclinations and periods, so that no less than twenty-two years are required for VI to gain one revolution on VII. Mr. Crommelin considers that this indicates a common origin for the two bodies.

Phoebe and Planetary Inversion. Last year Professor Pick-

ering threw out the suggestion that the rotation of Saturn was originally retrograde, and that solar tides reversed the sense of its motion after Phoebe was produced, but before the production of the inner planets. Mr. T.F. M. Stratton has treated this suggestion mathematically, and concludes that not only Phoebe, but also Japetus and Hyperion were shed whilst Saturn's obliquity was over 90°, but that the two larger satellites moved over with the planet's equator whilst Phoebe sank down to the ecliptic in a retrograde orbit. Uranus experienced feebler solar tides, and its satellites were evolved at an earlier stage than the large inner satellites of Saturn; the Uranian satellites have therefore stopped the decrease in obliquity arising from the solar action and are now driving Uranus back to the stable position with an obliquity of 180°. Neptune's one satellite has a large tidal influence and is driving its primary back also to equilibrium position with an obliquity of 180°. Mr. Stratton's work does not however give any explanation of the anomalous orbits of Jupiter's two outermost satellites.

The Stars. In the *Monthly Notices* for January 1906, Professor E. E. Barnard discusses the question of the proper motion and parallax of the Ring Nebula in Lyra. His measures of the central star of the nebula and of a twelfth magnitude star *a*, following it, made in 1898 and 1899, differed consistently from those made by Professor Burnham in 1891, the distance between the two stars apparently being diminished. In 1902, Dr. Newkirk investigated the proper motion and parallax of the nebula and found that its parallax was 0″.10, its annual motion being 0″.180, along position angle 303°.7, its motion tending to increase the distance of the nebula from the star *a* by 0″.75, in the five years since Professor Barnard has taken a series of measures in 1903-4-5 to verify Dr. Newkirk's results but fails to find any measurable change in the position of the nucleus or central star. He is driven to conclude that Dr. Newkirk's proper motion is not verified and that therefore the parallax of the nebula which depends on it, is not real.

In a valuable investigation on the Dimensions of an Algol Variable, in the same number of the *Monthly Notices*, Dr. A. W. Roberts finds that the distance between the component stars of U Pegasi is about 63,240,000 miles, and of RR Centauri, 3,800,000 miles, the orbit of this last star being practicably circular.

In the February number of the *Observatory*, Dr. Roberts also discusses the interesting case presented by the increasing period

of the variable star Beta Lyræ. Here there is no certain evidence of a closed cycle of orbital changes; the period of the system is apparently a constantly increasing quantity, though it increases by a diminishing rate. Notwithstanding this it is not probable that the variation is secular in character. Were it so, there must be a vast central controlling body, and an orbit which Beta Lyræ would take five centuries to traverse. But Dr. Roberts considers that the true reason is the slow recession of the component stars from one another; a very slight recession of one thousandth part of the radius of the orbit would account for the augmentation in time, 30 m. in a century. That the great tides which must act as a drag on the rotation period of the close binary, should in a century increase the distance of the components from 1.00061 to 1.00180 is not remarkable. Comparison of the light curves at intervals of fifty years seem to indicate change in the size and shape of the orbit, and there is also some evidence that the eccentricity is increasing.

Mr. Heber D. Curtis has contributed to the *Astrophysical Journal* for June a most valuable discussion of the system of Castor. He says that in Castor we have two systems whose orbital dimensions are probably of the same order of magnitude. The brighter component has however the very great eccentricity of 1.50, whilst the fainter pair revolve in orbits which are practically circular. This extraordinary difference seems to indicate that the brighter component is the older, and that the fainter is spectroscopically speaking, a binary of relatively recent origin. The mass of the fainter component should be about six times that of the brighter one.

It has been generally assumed amongst astronomers that at least a few stars are of extraordinary intrinsic brilliancy; Gill for instance gives the luminosity of Canopus as 20,000 times that of the Sun; and Kapteyn in No. 11 of the Groningen Publications says: "There will be a space which contains 2,000,000 stars of the same luminosity as that of the Sun one star with 100,000 times greater luminosity," thirty-eight stars with 10,000 times greater luminosity, 1800 stars with 1,000, etc., together with more than 12,000,000 stars of smaller luminosity than the Sun. In the *Astrophysical Journal* for April, Mr. G. C. Comstock gives reasons for concluding that there is no adequate evidence that the maximum of stellar luminosity requires more than three figures for its expression: nor that the mean luminosity of the first magnitude stars can be represented by a number with less than three significant figures. He considers that the

erroneously great values assigned to the luminosity of certain stars is the result of a transition from relative to absolute parallaxes. A few parallaxes have been left decidedly too small and have produced correspondingly great values of luminosity.

Professor E. E. Barnard draws some important conclusions from his photograph of the great photographic nebula which he obtained round Pi Scorpii. All the larger stars connected with the nebula, whose spectra have been observed, are of the Orion type. The Orion stars according to Professor Frost, are probably in a primitive condition and are also associated with nebulosities, whilst the converse seems to hold for stars of the more advanced types of spectra. Professor Barnard continues: "Such nebulæ as this one, and others of similar branching, straggling appearance, rather tend to make one doubt the generally accepted form of the nebular theory. Indeed this theory seems to have been built mainly upon the visual appearance of the nebulæ when seen in very inferior telescopes. It seems to me doubtful if the nebular theory would have been constructed at all if at the time our present knowledge of the appearance of the nebulæ, as shown by photography, had been available. It has always seemed to me that the nebular theory accounts for the existence of the stars in a very strained manner, and that it has very little to commend it."

"While there are some of the nebulæ (I do not speak now of the spiral nebulæ, that seem to agree in appearance with the theory, there is a much larger percentage that seem to be directly opposed to it. It does not appear necessary that the association of a star and a nebula proves that the star was formed from the nebula."

The Planetesimal Theory. A new cosmical hypothesis has been propounded during the past year by Messrs. Chamberlin and Salisbury. Instead of the extended and tenuous nebula of Laplace, or the sparse meteoric swarm of Lockyer, they hypothecate a central heliod with knots of denser aggregation which become the nuclei of the several planets. The constituents of the system might be molecules or small masses of any kind, moving in orbits about a common center, the essential point being that their behavior depends on revolution in independent orbits.

Double Stars. The most important event of the year in this department has been the publication by the Royal Astronomical Society of a great memoir by Mr. T. Lewis on the stars of W. Struve's *Mensuræ Micrometricæ.* This noble volume not only exhibits the complete observations made of over 3000 pairs

from the date of the discovery of each down to the present time, but orbits have been computed wherever possible, and the orbits deduced by other computers have been critically discussed, and if necessary, corrected. Two of the orbits thus discussed are of peculiar interest; Delta Equulei, the period of which used to be taken as 11.4 years, but which Professor Hussey showed to be really half that length, Mr. Lewis's discussion confirming the shorter period; and 61 Cygni, where the motion of the companion appeared uniform and rectilinear so long that some regarded the pair as merely an optical double. Mr. Lewis shows that there is now clear evidence for orbital motion, with a persistent wave of about ten and a half years' period. This wave is probably due to an obscure companion, and is quite a different one from that which Dr. Wilsing thought he had discovered from measures of photographs, with a period of twenty-two months and an amplitude of 0″.3. Professor Barnard has, however, observed the pair for more than four years, and has failed to find any evidence of the oscillation reported by Dr. Wilsing. A further point of interest in Mr. Lewis's Memoir is that by an ingenious use of the proportion existing in different parts of the sky, between pairs relatively fixed and pairs in orbital motion, he has been able to make an important contribution to the problem of the form of the general sidereal system, and has shown that the Sun is eccentrically placed within an egg-shaped cluster of stars.

Whilst by combining the known proper motions of stars with their orbital motions, he has shown that in twelve cases out of the eighteen examined, the fainter star is really the more massive, and in three cases more the masses are equal. In only three cases out of the eighteen, is the brighter star really the more massive, and even in these cases the disparity in mass is much less than in brightness. Further, in most of these pairs the fainter star is of a more bluish tint than the brighter, and is therefore supposed to be of the Sirian type of spectrum; a type hitherto supposed to be characteristic of stars of low density; not of very massive stars as seems to be the case. Evidently this may require ere long a reconstruction of some of our ideas of stellar physics.

The Systematic Motion of the Stars. In a paper read before the Royal Astronomical Society at its November meeting, Mr. A. S. Eddington discussed the Greenwich-Groombridge and Greenwich-Carrington proper motions with relation to Kapteyn's hypothesis of two star-drifts, and on the truth of this hypothesis arrived at the results that (1) The numbers of the stars belonging to the two drifts are nearly equal. (2) One drift is moving

relatively to the Sun, with a speed between three and four times that of the other. (3) The proportion of stars belonging to each drift is about the same in every part of the sky and at every distance here dealt with. (4) The magnitudes of the stars belonging to the two drifts are about the same. (5) The spectral types of the stars seem to differ to some extent in the two drifts but the evidence is not conclusive. (6) These results apply to all stars down to magnitude 9.5.

Danger to Greenwich Observatory. One event of the past year, though in itself not strictly astronomical, cannot be passed unnoticed in a summary of astronomical matters;—the threatened danger to Greenwich Observatory. The London County Council have been erecting a huge electrical generating station to contain eight engines working up to 52,000 horse power about half a mile north of the Observatory, and exactly on the meridian. Even now when no more than 3,000 horse power is developed the vibration sensibly affects observation with the transit-circles, and the four huge chimneys come almost into their fields of view. This danger to the efficiency of Greenwich is of course in the first place, a concern to British astronomers, but is not confined to them alone, for not only is science not a question of nationality, but in more than one respect Greenwich possesses a distinct international importance. Its meridian has been adopted as the prime meridian of the world by nearly all civilized nations, and the fundamental observations of the Moon's place have been practically committed to it by the general consent of the astronomical world. These and similar considerations, therefore, moved the Astronomische Gesellschaft at at their recent session, held in Jena, to pass a strongly worded resolution regretting the danger to which the Observatory was exposed.

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THE SIDEREAL DAY.

J. MORRISON. M.D; M.A., Ph. D.*

FOR POPULAR ASTRONOMY.

From time immemorial, the sidereal day has been classed among the so-called Astronomical Constants, that is, the time during which the Earth performs one absolute revolution on its axis,

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has been regarded as *invariable*. We purpose to show in this short paper, that, owing to the nature of the circumstances on which it depends, this assumption cannot be true. In order to obtain a clear view of the causes, which are continually operating to produce a variation in the duration of the sidereal day, we must go back a long way and briefly review the geologic history of our planet as revealed to us in the structure and conformation of the rocky pages of its crust or surface. There is good reason to believe that the matter composing the Earth once existed in a gaseous condition, having been thrown off or detached from the solar globe when its volume extended or filled the Earth's present orbit. This is a well founded assumption in harmony with the Nebular Hypothesis and is abundantly confirmed by all the structural and dynamical features of the solar system.

The irregular gaseous mass detached from the solar globe—and which subsequently became the Earth—would of course receive a motion of translation from the parent mass and also a motion of rotation around an axis passing through its center of gravity. While in this gaseous condition it abandoned or set free a portion of its own mass which became the Moon, but as this comparatively small mass rapidly cooled by the radiation of heat, the surface soon became too viscid to repeat the process. By the mutual attraction of its own particles, this gaseous mass would finally assume an approximately spherical figure and the duration of its axial rotation could not then have differed much, if any, from the Moon's present sidereal period, viz. 27 days 7 hours. As the cooling proceeded rapidly by the radiation of heat, contraction of volume would ensue, and the axial rotation would be accelerated in accordance with well-known dynamical principles which will be explained presently.

At the very high temperature which must have prevailed during this long period while in a gaseous condition, all the chemical elements of which the mass is composed—about 67 in number—were dissociated or existed in a free or uncombined state, but when the temperature declined to a certain point, chemical affinity would assert its power and combinations of the various elements would ensue. Oxygen and hydrogen would unite to form water in the form of vapor or steam; oxygen and carbon to form carbon dioxide; calcium and other metals would combine with oxygen to form oxides of these metals, and so on. In process of time as the mass cooled, the aqueous vapor would condense and showers of rain would be precipitated on the hot surface to be sent back again and again as steam. By a repetition of this

process, the temperature would eventually become lowered to such a degree that water would collect on the surface and thus would be formed a universal ocean of warm water highly charged with carbon dioxide and holding in solution carbonate of lime and other chemical substances which would be precipitated to the bottom and thus a solid crust of limestone would be formed. As the cooling proceeded now however more slowly than formerly, the gaseous interior would contract or shrink away from the crust forming extensive cavities bridged over, just as the water of a frozen river or pond falls away from the ice on its surface. When the crust increased in thickness by the deposition of sedimentary matter from the super-incumbent ocean, a tremendous strain would be produced in it, and when it could no longer be borne, extensive rents or cracks would be made, collapse of the crust on the molten matter beneath would occur and enormous masses of molten or igneous rock would exude through the cracks, technically called "faults" and thus mountains were born. This condition of things is well illustrated in the Laurentian Mountains in northern Canada, which extend in the form of a circular arc from the eastern coast of Labrador to near the mouth of the Mackenzie River and form for themostpart, a water-shed for the streams flowing south into the St. Lawrence, the Great Lakes and the Mississippi and those flowing north into Hudson Bay and the Arctic Sea.

The eastern end of this chain is a continuous solid wall of granite of immense magnitude, but the western portion consists for the most part of rounded off hills and isolated peaks the result of extensive erosion in subsequent geologic ages.

This mighty wall of granite was pushed up in a molten condition through the comparatively thin overlying crust of limestone which still rests, in some places, against its sides like the sloping roof of a house. These ancient limestone strata show evidence of having been subjected to a very high temperature. This extensive mass of igneous rock is the oldest portion of our continent and furnishes today, the most positive evidence of the condition of our globe which we have just described. Concurrent with this mighty upheaval which occurred during the Azoic period, that is, ages before the dawn of animal or vegetable life—there must have been a sinking or settling down of the entire surface or in other words a shortening of the axes of the Earth with consequent accelerated axial rotation.

After the lapse of an immensely long period to be counted only by millions of years and comprising the greater part, if not the

whole, of what is called the Palæozoic Period during which enormous deposits of sedimentary rock were laid down at the bottom of the ocean there occurred another tremendous upheaval when the Appalachian Mountains were born of the deep—an upheaval which must have shaken the Earth to the very center.

This mighty range extends under different names, from near the mouth of the St. Lawrence to northern Alabama and was at first of great height—so high that in some places it toppled over, thus burying the recently deposited strata far below the more ancient.

Another geologic age rolls by comprising nearly the whole of the Mesozoic Period when another tremendous convulsion shattered the crust for thousands of miles and the Rocky and Andes Mountains emerged from beneath the briny waves. These great seismic disturbances were the result of foldings or crumplings of the crust which had bridged over enormous cavities formed by the shrinking of the molten or gaseous mass beneath, and consequently these must have been at the same time a great subsidence of the general surface, but by reason of the great thickness of the crust no molten or igneous rock appears to have been protruded as was the case when the Laurentian Mountains were upheaved. Again after another long interval of time had rolled away, the glacial period arrived during the passing away of which, the Laurentian and Appalachian Mountains were planed down to their present dimensions; the debris of the former consisting of sand, gravel and boulders, was distributed over the southern portion of Canada and the adjacent portions of the northern States, and that of the latter spread out to the south and east to lay the foundation of what subsequently by another seismic disturbance, became the Atlantic coast states. These crumplings of the crust which resulted in the birth of the Appalachian, Rocky and Andes systems of mountains, must have produced very extensive cracks or faults in the crust and it is along these that seismic disturbances occur. One of these is believed to extend from New England along the Atlantic coast to the West India Islands and probably into South America, and another along the Pacific coast of Canada, the United States, Mexico, Central and South America to Tierra del Fuego in southern Chile. The Charleston earthquake of 1886 was on the former and the recent earthquakes of San Francisco and Valparaiso of 1906 along the latter. Another very extensive fault, no doubt, runs through the Alaskan peninsula, the Aleutian Islands, Kamchatka, the Kurile Islands, Japan, the Philippines, Formosa,

Java and Sumatra, for this region is notorious for its seismic disturbances which have been not only very numerous but also very destructive to life and property. Southern Europe is traversed by another fault extending through southern Portugal, Spain, Italy, Greece, Turkey and probably on through Asiatic Turkey, southeastern Russia, Persia and India. Hot springs, active and extinct volcanoes abound along these faults.

Beginning on the east coast of Greenland we have Jan Mayen which has been in a violent state of activity ever since its discovery, Hecla and numerous boiling springs in Iceland, several active volcanoes in the Alaskan peninsula and the Aleutian Islands, while Kamchatka, the Kurile Islands, Japan, the Philippines, Java and Sumatra fairly bristle with these fiery outlets. Europe has three active volcanoes, Vesuvius, Stromboli and Aetna. Mexico, Central America and the entire chain of the Andes are alive with volcanic activity, so also are the West India Islands, the Sandwich Islands, New Zealand, the Canaries, and the numerous islands in the Pacific Ocean and lastly we have two terrific volcanoes in the south frigid zone, viz., Mounts Erebus and Terror which have been in a violent state of activity since their discovery by Captain Ross in 1841.

These numerous outlets of subterranean heat must produce a decided effect in lowering the temperature of the molten interior with corresponding contraction of volume. Cavities are thus formed beneath the crust which finally collapses and a folding or overlapping of the edges of the fault produces an oblique downward motion sufficient sometimes to twist or wreck the foundations of the strongest structures man can erect. The fall of even a few inches of the solid crust which may vary probably from seventy to a hundred miles or more in thickness, would produce a shock or vibration which would doubtless be felt for a thousand miles or more.

Ever since the Spanish occupation of South America, seismic disturbances of a more or less violent character have occurred especially along the Pacific coast—the last being that of August, 1906. In 1730 Valparaiso was almost completely ruined by an earthquake of unusual violence; in 1822 Santiago was partially destroyed and a long portion of the coast of Chile permanently raised, and in 1829 the same city was again visited and the elevated coast depressed several feet below its normal level. In 1835, 1849 and 1851 violent earthquakes occurred in Chile, the last being especially destructive in Valparaiso in which over four hundred houses were wrecked and several lives lost. In 1880,

Iliapil, near Valparaiso was destroyed and over two hundred persons perished. In 1885, the islands of Santa Maria and Concepcion off the coast of Chile were uplifted and subsequently depressed eight feet below their former position. This earthquake was felt for more than a thousand miles along the coast. It is very probable, nay almost certain, that not only the portion of the coast, and the above-mentioned islands, but also a large portion of the Andes and a large area of the floor of the ocean were depressed at the same time. On August 13—15, 1892, Peru was visited by one of the most destructive earthquakes on record, four cities and several towns were wholly or partially destroyed and over twenty-five thousand persons perished. The entire Pacific coast of South America has frequently been more or less submerged by tidal waves the result of submarine eruptions which are very probably three or four times more numerous than on land one having recently taken place near Hawaii where vast numbers of cooked or boiled fish were washed ashore; another off the coast of Alaska where a new island has been formed, thus increasing the domains of Uncle Sam, and it is reported that the island of Juan Fernandez, some five hundred miles west of Valparaiso, has disappeared by the subsidence of the floor of the ocean.

In the early part of the last century, about 1834, a new island, Graham's Island, was heaved up in the Mediterranean southeast of Malta, and remained for a year or more when it gradually sank out of sight, an extensive shoal still remaining.

In June 1773, Santiago, Guatemala, was completely wiped out together with nearly all its inhabitants and quite recently the volcano Santa Maria in the same republic, violently erupted and destroyed an immense amount of property in its vicinity.

When faults extend under oceans, water percolates down to the heated interior where it is converted into superheated steam which ultimately bursts out at the point of least resistance with terrific violence. The explosions of Krakatoa, in 1882, and of Mount Pelée in Martinique which recently wiped out the city of St. Pierre, were of this kind and probably all submarine disturbances are of the same character.

Another region notorious for seismic disturbances, is the south of Europe extending from the south of Portugal to Asiatic Turkey and in fact on through the Caucasus and Persia to Hindostan. Vesuvius, Stromboli and Aetna have wrought frightful destruction of life and property during the last three thousand years. The fate of Pompeii and Herculaneum is well-known. On February 26, 1531, Lisbon, the capital of Portugal, was partially

destroyed, fifteen hundred houses, were more or less wrecked and about thirty thousand people perished, and again on November 1, 1755 a large portion of the same city sank and about sixty thousand persons were engulfed beneath the Atlantic. This collapse of a portion of the Earth's crust produced a shock or vibration which was felt five thousand miles away. The same catastrophe befell Port Royal, in Jamaica, West Indies during the early part of the last century and ships now sail over where a portion of Lisbon once stood as well as over Port Royal.

In 1851 the south of Italy was visited by an earthquake which caused the death of about nineteen thousand people, and again in December 1857, and also quite recently, several towns in Italy were partially ruined and ten thousand persons perished. During the last century numerous shocks or vibrations have been felt in Greece, Turkey, the Caucasus region, Asiatic Turkey, India and China which were attended with great destruction of property and loss of life. Antioch on the Orontes, in Asiatic Turkey was almost ruined during the early part of the last century and about the same time an earthquake occurred in southeastern Missouri in the neighborhood of New Madrid causing a subsidence of the ground and the formation of several small lakes which still remain. While this paper is being written, news is received of slight earthquake vibrations in Maine. In short, there is no part of the Earth's surface absolutely free from seismic disturbance. The three regions most noted for these phenomena, are the south of Europe, the west coast of South America and the east coast of Asia. A Japanese observer has recorded several hundred seismic vibrations during the last two or three years. These were all the result of the slow settling down of the Earth's crust in that particular region. Among other noted depressions of portions of the Earth's surface may be mentioned that which occurred in Western Asia during the time of the Patriarch Abraham. The plain on which the cities of Sodom and Gomorrah stood, sank, the Dead Sea was formed and the River Jordan arrested in its course. This historic river formerly flowed into the Gulf of Akaba which forms the northeastern extremity of the Red Sea through a channel still well defined. The Dead Sea, a considerable tract of country around it, and the entire valley of the Jordan are now more than a thousand feet below the level of the Mediterranean. A similar condition of things exists in the case of the Caspian and Aral Seas. There is also a large area of depression several feet below the Caspian, in southeastern Russia.

Several monuments and columns which stood high above the

Mediterranean in Pliny's time, are now wholly or partially submerged, the coast for many leagues having sunk several feet. From the facts already mentioned there is good reason to believe that large areas of the floor of the Pacific Ocean are slowly settling down.

Seismic disturbances of great magnitude appear to be going on in northern Canada. The eastern shore of Hudson Bay is rising and the western shore sinking, new islands have appeared and the Bay is becoming shallower—all within the memory of persons now living on its shores.

Eminent geologists say that the north shore of Lake Superior is rising and the southern shore subsiding and that in eight hundred or a thousand years the Great Lakes on our northern borders will find an outlet in the Mississippi. According to researches carried on by the U. S. Coast and Geodetic Survey the North American continent is floating on an elastic sea of molten or gaseous material. All these movements appear to indicate that the continent or at least the northeastern portion of it is canting over to the southwest.

Certain distinguished scientists entertain the opinion that the interior of the Earth must be "solid and as rigid as steel". In a gaseous condition it certainly was when detached from the parent body which subsequently became the Sun, and in a liquid or semi-gaseous state when the Laurentian Mountains were thrown up, for the upheaved matter penetrated all the fissures and cracks in the upturned overlying strata. As a matter of fact, volcanoes still pour forth *liquid rock* or lava which is probably gaseous at great depths. Owing to the tremendous pressure at the depth of even a thousand miles below the surface, the temperature must be very great, far surpassing any temperature we can produce, and therefore all the chemical elements must be dissociated. Now there is a temperature common to all gases *above which they can not be condensed by any pressure*; this is the *critical temperature*. Hydrogen, oxygen, methane, carbon dioxide and other gases have been subjected to a pressure of 3,600 atmospheres without condensing them, because the temperature employed was far above the critical temperature belonging to that particular gas. Again, all liquids when heated above the critical temperature, are transformed into gases although subjected to intense pressure. A pressure of 74 atmospheres and a temperature of 31 degrees C., are required to liquefy carbon dioxide, but *above this temperature* no pressure whatever would condense it. The critical temperature of the metals in a gaseous condition must of course be vastly

higher but far below the temperature which must exist in the interior of the Earth. In consequence then of these critical conditions of matter, the interior must be gaseous, condensed probably to the consistence of tar, but liquid when emitted by volcanoes; it can not then be solid, much less as rigid as steel.

By reason of these subsidences of portions of the Earth's crust, embracing, no doubt, large areas of continents and oceans and especially such as have occurred at various times on the west coast of South America, the position of the center of gravity of the Earth must undergo a slight change, and as the axis of rotation must pass through this point, the position of the Earth's poles can not be permanent but must also be subject to a slight movement and therefore a slight variation in the latitude of places must take place—a variation which has already been established by direct astronomical observations at several observatories. The shifting of the poles through a distance of 101 feet would produce a change of latitude which would attain a maximum value of $\pm 1''$. Moreover the subsidence of the general surface will reduce the length of a degree of latitude and also increase the weight of bodies on the surface. It is quite evident then that an exceedingly slight change in the position of the center of gravity would be fully sufficient to account for the variation of latitude which has actually been found to have taken place in recent times amounting to about $\pm 0.5''$ in some places.

But these very slight variations resulting from the partial or general subsidence of the Earth's crust, are practically of little or no importance and utterly insignificant in comparison with another variation, viz., that of the shortening of the length of the sidereal day, which, as we shall see, must constitute a serious disturbing factor in our lunar, solar and planetary tables.

As a result of the seismic disturbances already mentioned—and these are but a small portion of those which have actually taken place within the dates recorded—it is not perhaps too much to assume that the Earth's radius has been reduced by, say, four feet during the last century, and for the sake of illustration we will take four feet.

Let R = the Earth's radius in, say, 1800
r = " " " " " 1906
F = acceleration of gravity in 1800
f = " " " " " 1906
V = velocity per second in 1800
v = " " " " 1906
T = duration of one absolute revolution in 1800
t = " " " " " " 1906

where R, r, F, f, V, and v are expressed in feet and T and t in seconds.

Then we shall have by a well-known formula in dynamics:

$$F = \frac{V^2}{R} \qquad \text{and } TV = 2\pi R$$

$$f = \frac{v^2}{r} \qquad \text{and } tv = 2\pi r$$

$$\text{Whence } \frac{F}{f} = \frac{V^2}{v^2} \cdot \frac{r}{R} \quad (1), \text{ and } \frac{V}{v} = \frac{R}{r} \cdot \frac{t}{T} \quad (2)$$

By the theory of attraction we have

$$f : F :: R^2 : r^2 \quad \text{whence } \frac{F}{f} = \frac{r^2}{R^2} \quad (3)$$

From (1), (2) and (3) we easily find

$$\frac{t}{T} = \left(\frac{r}{R}\right)^{3/2}$$

$$\text{whence } t = \left(\frac{r}{R}\right)^{3/2} T \quad (4)$$

From the Clark Spheroid of 1866, adopted by the U. S. Coast and Geodetic Survey we have:

R = 20926062 feet, hence r = 20926058 feet and T = 86400 sidereal seconds.

The coefficient of T in (4) is .999,999,784,957,059 and therefore t = 86399.9814202898976 seconds and T − t = .0185797 seconds, or the sidereal day in 1906 is very nearly one fifty-fourth of a second shorter than it was in the year 1800.

This assumption of a reduction of four feet in the radius during a century may be, and probably is, too large. A reduction of two feet in the radius will shorten the day about one one-hundred-twenty-fifth of a second.

This slight variation in the length of the sidereal day is certainly the disturbing factor in our lunar and other astronomical tables.

Hansen's lunar tables prepared about half a century ago gave the Moon's place very accurately for several years, but during the last two or three decades the discrepancy between the computed and observed places of our satellite, is increasing, and to such an extent that one astronomer has prepared and published an "*Empirical Correction*" to be applied to the computed place to make it agree more closely with the observed or actual place—a species of astronomical tinkering not only vicious in principle bnt also inconsistent and unscientific.

In Hansen's tables the time was taken as the independent variable, but as the sidereal day most certainly varies it will not be very difficult to make an adjustment in accordance therewith and when such is judiciously made, it will doubtless be found

that the tables are as accurate and trustworthy now as when first issued.

The variation of the sidereal day will also operate to produce a discordance in the case of the solar and the planetary tables. Again, the recorded dates of ancient eclipses—that of Thales for example—can not be even approximately verified on the assumption that the sidereal day is a constant and invariable interval. During the time of Thales the sidereal day may have been a minute or even more longer than at present. In remote geologic ages when the radiation of heat from the Earth must have been immensely greater than at any subsequent time vast areas, perhaps entire continents, may have settled down or become deeply submerged, and this irregular or partial subsidence may have produced a great change in the position of the center of gravity and consequently great movements in the poles—ten or twenty degrees or more—resulting in a great variation of climate which we know once existed in high northern latitudes. There can be no doubt but that seismic disturbances have always, and are still, slowly operating to produce great changes in both the structural and dynamical circumstances of our globe, and thus it is, that "change and decay in all around we see" thoughout the entire realm of creation.

THE ORIENTATION OF THE FIELD OF VIEW OF A TELESCOPE.

E. T. WHITELOW.

For Popular Astronomy.

Several times I have been asked by members of the Manchester Astronomical Society, who are users of reflectors, for hints as to how to determine the cardinal points of the field of view which appear to change so erratically when the telescope is shifted from one side of the stand to the other, or when rotated in its cradle. Similar questions arose with users of solar or stellar reflecting eyepieces and spectroscopes. Troublesome as the subject is to beginners in practical observation (and even to some of us who are hardly beginners) there does not seem to be any reference to it in text-books or manuals. The recent correspondence in the *English Mechanic* shows the matter to be of somewhat wide interest.

Mr. Whitmell's excellent summary, in the *English Mechanic*, of the varied aspects of the field of view is complete and correct for the position he has chosen, viz., a horizontal telescope pointing

south. If however the telescope is turned up to a point between the zenith and the pole a new set of diagrams is required to illustrate the orientation; still other aspects present themselves when the telescope is directed east or west. It is *off* the meridian that the difficulty arises. Yet the whole matter is very simple and every possible case can be treated as one of two typical aspects. Let us take the simplest case first. Remove the object glass and eyepiece lenses from any kind of refracting telescope. Hold the instrument stationary just in front of the Moon when about to cross the meridian and observe the Moon crossing the field of view. We have then the condition shown in Figure 1. The Moon enters at the *E* side and leaves at the *W* side (the dotted circle indicates the Moon when in the center of the field). We may

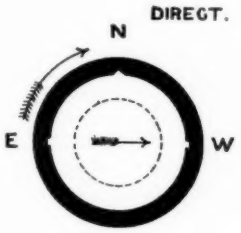

FIG. 1.

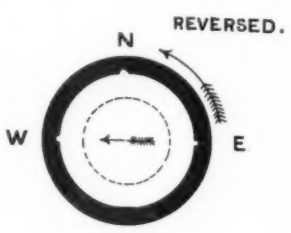

FIG. 2.

term this the direct aspect. Let *E* stand not only for East but also as a mnemonic for *entering* point. The apparent *N* point is of course between the *E* and *W* points which are always easily determined by allowing an object to cross the field.

The only important thing to remember is that in the direct aspect the *N* point is always 90 degrees *clockwise* from the *E* point.

We may rotate Figure 1 on its center in the plane of the paper, so as to make the *E* point occupy any position whatever on the circumference so as to correspond to the aspect of the field of view of the telescope in any position, without changing in any way the relative positions of the cardinal points—*N* remains invariably clockwise from *E*.

It does not matter what system of lenses we interpose between the eye and the object, whether an inverting or a terrestrial eyepiece or whether we are using a Galilean or an astronomical telescope, or a photographic camera if we look *through* the focussing screen, *N* is 90 degrees clockwise from *E*.

If now we interpose a single reflecting surface in the path of the rays from the object to the eye, say a single solar diagonal,

we shall then see things in a *reversed* aspect as shown in Figure 2. The *E* and *W* points are determined by the direction of motion through the field or in the direct aspect. A celestial object still enters at *E* and leaves at *W* but the order of the cardinal points is reversed and the *N* point is now *counter-clockwise* from the *E* point. It does not matter how we rotate the diagonal eyepiece, or what part ot the sky we look at, or which side of the telescope we observe from. The *N* point may be at the top of the field or at the bottom or at the right or the left or at any intermediate position, it is always found counter-clockwise from the *E* point.

This reversed aspect is also that in which we observe the projected image of the Sun as seen *reflected* from the surface on which it is projected. It is also that of an ordinary diffraction spectroscope having a reflecting grating, and is generally the condition where there is an odd number of reflections (no matter how many) as in the case of the Newtonian reflector when used with a single diagonal eyepiece.

The introduction of such expressions as semi-inversion rather beclouds the matter. Figure 2 is a case of simple reversal of Figure 1.

If however we interpose an *even* number of reflections (no matter how many) as in Thorpe's solar eyepiece, in the Newtonian or Gregorian reflecting telescopes, or in the case of a diffraction spectroscope having a reflecting grating and a diagonal eyepiece, the reversal is corrected and we have again the direct aspect of Figure 1 and the *N* point is always clockwise from the *E* point.

When formerly using a Newtonian reflector I filed notches in the diaphragm of one of my eyepieces as shown in the figures, viz., two square notches opposite each other and a V notch between. To orient the field the eyepiece is rotated so that the object crosses from one square notch to the other and the V notch is clockwise from the entering notch. For users of telescopes mounted in altazimuth stands this little device is of service for estimating the position angle of a double star or the approximate position of a new sun-spot.

In the comparatively rare case of directing the telescope to a field *containing* the pole the orientation from a simple inspection of the field is not so simple, and a mistake is easily made, even by experienced observers. In such cases, south is at the top and bottom of the field at the same time in the direct aspect as seen by a refracting telescope.

Birkdale, England.

A PLEA FOR ELEMENTARY ASTRONOMY.

MARY E. BYRD.

FOR POPULAR ASTRONOMY.

Science is rapidly coming to her own in our high schools and academies. The claims of physics, chemistry and biology are now widely recognized, nor is it held as a valid objection to any one that all of them can not be offered in every high school nor all students profit by those that are offered. Each science has its natural clientage, its individual handicaps and advantages that make it unwise to press it under certain conditions and highly important to urge it for other schools and other students.

For astronomy it may be said that its handicaps are like those of real life. Because it can not be taught according to a fixed, mechanical routine, because its exercises can not all be set for definitely assigned periods, and its material doled out in specific quantities, for these very reasons it is one of the best studies if the aim is to fashion strong character and develop brain power. Students of necessity learn to be self-reliant and resourceful. They constantly get stimulus for rapid, independent thinking and are often led to discover and invent, using the terms in their literal sense. In passing, it may be noted that the kind of exercise obtained incidentally, out of doors in pure air, vies with some gymnastic courses in promoting health. Nor is it a disadvantage for young students to reap the benefit and enjoy the pleasure of scientific study without mutilating, killing and destroying, and I may add, without bad smells!

Astronomy was the science for the childhood of the race and as child-development along broad lines, follows that of the race, the elements of practical astronomy are especially adapted to young students. Their interests are more closely associated with the world out of doors than when they grow older. Their games, picnics, rides, and sails are often connected with sunny afternoons and moonlight or starlight nights. It needs little if any effort to arouse in them a wholesome curiosity about the greater and lesser lights of heaven, a curiosity that leads to watching and thinking and finding out. To them the characteristics of the study, which seem objections to teachers of the martinet type, are attractions. Their instinctive activity, the quick turning from one thing to another make it natural for them to observe different celestial bodies at different times and places. Their mental digestion at this stage of growth is not so well adapted to getting knowledge in solid chunks as to taking a little here and a

little there. The innate freedom and pleasure of the subject make it possible to insist without burdensome friction npon that precision in seeing and care and exactness in recording which lie at the foundation of all scientific work.

Few things taught in school remain so permanently a part of life as knowledge gained early of the bright constellations, the changing Moon and the evening stars. If once their acquaintance is made it is easy to keep. No books, no cumbersome apparatus need be carried about. The illuminated scroll of the heavens is always unrolled. Wherever one lives, wherever one journeys, on sea or land, as long as life, and eyesight last, there is special joy in looking up for those who in youth made friends with the stars.

If the proper study of mankind is man, astronomy should by all means be studied, for this science more than any other is bound up with the history of the race from prehistoric times. The first tillers of the soil doubtless knew when to plant and to harvest by the rising of certain constellations. Those who first sailed far from coast lines must have learned to guide their course by the stars about the pole. The earliest religions were little else than varied forms of Sun and star worship. Literature came into being to express this worship and architecture to build its external shrines. Later when less exalted ideas held sway in religion, all its rites and ceremonies were still ruled by signs and aspects in the heavens. The priests were of necessity astronomers. It was their duty and prerogative to construct the calendar. This seems perhaps a little thing; but with the great nations of antiquity it was reckoned, and not unwisely, among their proudest boasts that they had, in very early times, constructed a calendar and predicted eclipses.

If we would get glimpses into the heart of past civilizations, astronomy aids us. There is warm human interest in the beautiful worship of the dawn and the god of day that permeated the manner of life in ancient times on the banks of the Nile. It means little that Sargon, the Babylonian Solomon, was a conquerer, it was in those ages the business of kings to conquer, but that he founded a great library whose priceless treasure was the astronomical work known as the "Illumination of Bel," that gives him right to live in history. Ur of the Chaldees, and Nineveh in Assyria were famous for many things, but we touch the pulse of their strong life in their temple-observatories. There the royal astronomers watched and studied planets, comets, Sun, Moon and stars, and utilized their various researches in casting hor-

oscopes and constructing calendars. The age-long struggle of ancient peoples to perfect the calendar played an important part both in their intellectual life and in their political history. Kings and princes aided in the undertaking. It was one of the great perennial interests. Observatories were built by royal decree, fell into ruins and were built again, to correct the calendar; different nations made their contributions, and when, in 433 B.C., a real though not final triumph came through a Greek, and the cycle of Meton was proclaimed, it marked at the Olympic games not only an epoch in astronomy but in universal history.

Astronomy led the thought of the world in the centuries coming just before and after the opening of our era. All sciences were then parts of astronomy; not only navigation, geography and geodesy but physics, mathematics and philosophy. Euclid, Plato and Aristotle are rightly reckoned among astronomers. In later times many other royal intellects have been nurtured by astronomy and contributed to its triumphs. It suffices to mention Copernicus, Tycho Brahe, Kepler, Galileo and Newton. Hardly less worthy are Leverrier and Adams who by their discovery of the planet Neptune won a triumph that is often ranked as the greatest of the human intellect.

The fortunes of the nations of medieval and modern Europe, their traditions, superstitions and politics were influenced not a little by true and false beliefs in astronomy. Rival schools of the science left their impress both on Church and State. The occurrence of total solar eclipses, the appearance of great comets, the flashing out of a new star, the invention of the telescope and its revelations were matters of concern to whole peoples. The greatest were none too great to be the patrons of astronomy, the tools for its work were held worthy to be gifts to kings, and its discoveries were the pride of states. Thus we see astronomy like a golden thread running through history and binding together all tribes and peoples of the Earth. As Emerson says:

"I am brother to him who squared the pyramids,
By the same stars I watch."

Astronomy is a living science. At a number of points it touches every-day life. The common almanacs are compiled from the astronomical year books, time is determined at observatories and distributed from them, navigation still depends implicity upon astronomical predictions; extended surveys latitude and longitude require astronomical observations. Some of the latest researches at the new solar observatories are along practical lines; and many of the present-day problems in astronomy can

be stated in simple terms and are easy to follow and understand in their broad outlines. Observatories were never before so many in number nor so wonderfully equipped with every thing that the human mind can devise and the skilled hand execute. The work of astronomers is still held among objects of national pride, discoveries are matters of almost daily occurrence, some of them dramatic in character, and no wonder, for of late years astronomers have taken the Sun for a workshop and the stars for experiment stations.

In astronomy, I believe, is found the key to one of the difficult problems that confronts our public schools, how to nurture the growth of that which is spiritual in the average girl and boy. To perceive and enjoy beauty, to be touched by wonder and mystery, to feel awe and reverence, to worship—these things are not taught directly. Poetry and literature give some help, but for the young they are not natural interpreters but themselves stand in need of interpretation from external realities. It is not then surprising, perhaps, that many young students eschew literature in all forms and others make of it an ungrateful, laborious task that utterly fails of the higher ends sought. On the other hand, if years of experience in many schools in different states is any criterion, there are few who do not readily become eager and assiduous star-gazers, and those who watch the stars by night learn many things that are not set down in the lessons of the astronomical course. How better can we hope to win for our students part and lot in the deep things of life than by introducing them to the science of astronomy? Do we wish to put meaning into the concepts of infinity and eternity? Astronomy in its common routine deals with distances that reach on and on till thought itself is weary. Its measures of duration are eons of time, it confidently ventures to explore ages before man's life began and makes predictions that must wait their fulfillment till our little Earth with all its teeming interests has passed away as a tale that is told. Do we look for examples of the power of mind over matter? It is the part of astronomy to weigh the planets and to find out their mass, to divine the constituent substances of bodies beyond our solar system, and tell the light-year of the stars. Do we seek to present illustrations of beauty and sublimity? Where are they more lavishly displayed than in the blue vault of heaven, spanned by the arch of the Milky Way, with the bright planets lighting the east and the west, and overhead Taurus with the Pleiades, the Hyades, and its red star Aldebaran, and Orion with the wonderful nebula.

Would we waken high ideals of Deity? "The heavens declare the glory of God and the firmament showeth His handiwork."

It is this science, the mother of sciences, for which I plead, that it may receive more consideration from the wise commissioners that formulate the courses of study in our schools and gain more supporters from the body of our teachers. Is it not worthy of at least so much, a science that nurtures the understanding and the imagination, that interprets and vivifies history, that has enriched all literatures of all peoples, and given to religion its language of lofty symbolism.

Lawrence, Kansas.

TELESCOPIC METEORS.

JOEL H. METCALF.

For Popular Astronomy.

While comet seeking during the past three summers I have been greatly struck with the large number of telescopic meteors which shoot across the field of view with startling velocity. As with the naked eye meteors which range in brightness from the beautiful rocket-like objects that call out exclamations of wonder, to the faintest which one sees and then is immediately in doubt as to whether he did see, so evanescent and faint were they. So in the comet seeking telescope on the one hand the observer sees brilliant ones which almost frighten by their sudden and brilliant apparition and on the other, faint ones that come and are gone before the attention can be fixed upon them.

During three summers in Vermont I have searched for comets on nearly every clear moonless night and I have kept a mental record of the number of telescopic meteors which could not have been visible to the naked eye. It very rarely happened that I saw less than one an hour and on one night last August I counted twelve in two hours comet seeking.

I feel confident that I do not overstate the case to say that I have averaged two telescopic meteors per hour for the past three summers.

In looking up the experiences of other observers I find quoted in the Sidereal Messenger of Jan. 1884 the observations of Professor Wm. R. Brooks. He says while sweeping on the evening of November 28th: "It was my pleasure to observe a wonderful shower or flight of telescopic meteors about ten degrees above the horizon and near the sunset point. They were very small

none of them visible to the naked eye, most of them leaving a faint train visible in the telescope for one or two seconds. The motion of most of them was to the northward with an occasional group to the south of the Sun moving northward."

His closing sentence in a note is the point to which I wish to call special attention. "The faithful comet seeker frequently in a single night's work encounters *numerous* telescopic meteors *singly*, very rarely two at once."

In Popular Astronomy Vol. 5 page 441, Zaccheus Daniel says: "On nearly every night since February 24 I have seen one or more meteors with the 4-inch telescope equipped with an eyepiece having a power of eighteen and a field of 2° in diameter. The average number was one or more per hour. The most of them were faint."

These are the only references I have at hand in relation to the average number of telescopic meteors seen by comet seekers though I find some reference to showers of telescopic meteors seen during eclipses.

It is to be hoped that Professors Barnard, Denning, Swift and the continental comet seekers have kept records of the number of telescopic meteors they have seen in their comet work and will publish their results, or that comet seekers in the future will preserve such data, for if telescopic meteors are anywhere nearly as numerous as my small experience would suggest the fact is of great significance.

My 7-inch comet seeker of the "broken backed" type has a field of 1½° with the eyepiece generally used. The length of the trails of telescopic meteors is unknown and it seems to me must for a long time remain a matter of guess work. The presumption is however that the smaller meteor would have a proportionately shorter flight. I will assume a length of 3° as an average and that for a meteor to be visible in the telescope its flight must be over a large part of the field of view, which supposition I think is true. This at the rate of two per hour in my telescope would represent for the whole visible horizon about 18,000 meteors per hour. A *shower* of meteors every night!

Professor Schmidt of Athens found that the average number of naked eye meteors was fourteen per hour for a single observer and that a large number of people watching every part of the sky would see six times as many. Assuming eighty-four as the average fall of unaided eye meteors the number visible in a small telescope is seen to be roughly two hundred times as great.

Argelander's Durchmusterung des Nördlichen Himmels, shows

in the northern hemisphere 485 stars from the first to 4.9 magnitude inclusive and 76.897 from 4.9 to 8.9. The increase of stars from those brighter than the fifth and those brighter than the ninth magnitude is about 150 times.

Turning now to the increase of meteors. It is not easy to estimate the brightness of the faintest meteors visible to the naked eye and with the telescope it is still more difficult but assuming the fifth magnitude for the limit of the naked eye and ninth magnitude in the comet seeker which I think is fairly near the truth, the increase of meteors seen in the telescope is larger in proportion than the increase of the number of stars, in our example as 150 : 200.

If the amount of light received from stars between the first and fifth magnitude is represented by 32.4 the amount of light received from the much larger number of fainter stars from 4.9 to 8.9 magnitude would be 110, more than three times as great. If the increase of meteors with telescopic power were exactly the same as the increase of stars we thus see that the amount of light from telescopic meteors would be three times as great as from those visible to the unaided eye, and light must be in direct proportion to mass. All things considered therefore I believe that the amount of matter received by us from telescopic meteors far exceeds the amount we receive in the larger masses which are ordinarily visible.

If our telescopic power were increased the presumption is the case would be much more striking.

Enough has been said I think to show that the subject of telescopic meteors has not received the attention it merits; the discussion of this article is necessarily vague and based on a very insufficient induction of fact. The true average of telescopic meteors has yet to be determined.

I feel however that we have enough fact to show the extreme significance of the subject. If telescopic meteors are anywhere nearly as numerous as they seem to me to be they bear witness to the existence of large quantities of highly disintegrated matter in the solar system. *Star dust* let us say in a true sense.

The existence of matter in such an attenuated form if in such large quantities must have significance not only in world building but may have relation to our interpretation of the zodiacal light, the Gegenschein or even the mysterious phenomena of comets' tails.

Taunton, Mass.

ON THE ANCIENT ECLIPSES OF THE SUN.* II.

E. NEVILL.

XII. *The Eclipse of Babylon.*—Recorded as occurring on the "26th day of the month Sivan in the seventh year." From the other details the eclipse was most likely a total eclipse with a vivid corona. Assuming that the eclipse occurred in the first half of the eleventh century it would seem certain that this eclipse must have been that of —1069 June 19, which occurred in the month Sivan, of the seventh year of E-Ulmas-sakin-sumi, King of Babylon, thus being a strict accord with the record. But as this eclipse could not possibly have been total at Babylon according to his adopted data, Mr. Cowell is led to substitute the eclipse of —1062 July 30. The discrepancy of seven years in the epoch of the king's reign might not be deemed fatal to this identification, owing to the uncertainty in these very early epochs; but can July 30 ever have been in the month Sivan, which corresponds with May or June? Could it even have corresponded with Tammuz, the next month, or must it not be held to be some day of the month after? As the inscription must be regarded as an actual record, the month cannot have been in error, and the record cannot be changed by reading Tammuz, or even some later month, for the Sivan actually recorded.

This eclipse of —1069 June 19 is the only one which occurred during the month Sivan which could have been visible as a total eclipse from Babylon during the first half of the eleventh century. There are annular eclipses in this month during this period, but they could not have been even large eclipses near Babylon, and there are other eclipses which might have been total near Babylon, but could never have been described as occurring in the month Sivan.

If it were permissible to assume an earlier epoch, then the record might refer to one of the kings of the Isin dynasty, and correspond with either the eclipse of —1116 June 28, or —1123 May 18, both of which may have been total at Babylon.

The values of $\Delta\phi$ for the preceding eclipses are:

	°	°	°	°
—1062 July 30	A = − 2.2	B = − 7.0	C = − 5.6	Cowell = + 0.8
—1069 June 19	= + 30.7	= + 13.0	= + 16.5	= + 12.3
—1116 June 28	= + 10.8	= − 6.9	= − 0.3	= + 4.0
—1123 May 18	= + 11.7	= + 1.2	= + 3.2	= − 2.1

It will be seen that the line of totality of the eclipse —1069

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June 19 cannot be brought over Babylon by any of the four systems of data or by any system within the limits of possibility. Hence, though otherwise in complete accordance with the recorded account, it cannot have been the recorded eclipse. The eclipse of −1062 July 20 can be made total at Babylon either by Mr. Cowell's data or by a slight modification of the very different data obtained by Hansen, and therefore by any number of intermediate combinations lying between the two systems. If it be adopted as the eclipse corresponding to that recorded in the cuneiform tablet, it must be held as of little use for indicating the true value of the secular acceleration; but the discordance between the month of the eclipse and that stated in the inscription must be held to render such an identification very doubtful.

Mr. Cowell does not give any reasons for assigning this eclipse to a period subsequent to −1100, nor does he state whether Mr. King furnished such reasons, nor even whether the rest of the inscription (by stating the king's name or dynasty) affords means for fixing such a limit. Unless such a reason exist for dating the record after −1100, the eclipse would seem more likely to have been that of −1116 June 28, or −1123 May 18, than that of −1062 July 30, since the eclipse of −1069 June 19 is out of the question, as not even large near Babylon. If the inscription permits of the recorded eclipse being identified with one of these earlier eclipses it would be most valuable for fixing the true value of the secular accelerations and motion of the lunar node, as it would clearly distinguish between the four representative sets of data.

The preceding comparisons show that the eclipses, which by slight permissible alterations in the assumed data may be represented by the four very different sets of assumed values for the secular accelerations and motions of the Moon's node, are as follows:—

		A		B		C		Cowell	
Eclipse of	Obs. Phenomenon.	Date.	$\Delta\phi$. °	Date.	$\Delta\phi$. °	Date.	$\Delta\phi$ °	Date.	$\Delta\phi$. °
I. Agathocles	Total	− 309	+1.8	−309	+0.8	−309	+0.8	−309	−0.9
III. Ennius ...	Large	− 399	−1.2	...	...	...	...	−399	+3.1
IV. Lysander	Large	− 403	−0.2	−403	+2.6	−403	+1.6	−403	−2.4
V. Thucydides	Nearly total	...	...	−430	1.8	−430	−2.8*	−430	+0.1
VI. Thales ...	Total	− 584	−2.0	...	...	−556	+1.0	...	...
						−584	+1.1	...	...
VII. Larissa ...	Total	− 556?	−0.6	−602	+0.2	−602	+2.0	−602	−0.6
VIII. Archilochus	Total	− 647	+0.3	−656	−2.0	−656	−0.7	−647	+0.5
				−703	+2.7	−703	+0.7	−688	−1.8

* Observed from the northern Ægean instead of Athens.

Eclipse of	Obs. Phenomenon	A Date.	A $\Delta\phi$. °	B Date.	B $\Delta\phi$. °	C Date.	C $\Delta\phi$. °	Cowell Date.	Cowell $\Delta\phi$. °
IX. Susa	... Large	— 660	+1.6	...	...	—660	+7.9	—660	+6.0
X. Esarhaddon	Large	...	...	—678	+5.6	...	...	—678	+4.8
XI. Nineveh	... Large	— 762	—4.1	—762	—6.7	—762	—5.9	—762	—0.8
XII. Babylon	Total	—1062	—2.2	—1123	+1.2	—1116	-0.3	—1062	+0.8
								—1123	—2.1

Mr. Cowell considers that the fact that the system of secular mean motions and accelerations adopted by him renders total the five eclipses

—1062	July	30	at	Babylon
— 762	June	14	"	Nineveh
— 647	April	5	"	Thasos
— 430	August	3	"	Athens
+ 197	June	3	"	Utica

is so remarkable that it cannot be held a chance coincidence, but must be regarded as demonstrating the accuracy of the adopted system. It is necessary to remember, however, in considering this claim—

That the eclipse at Babylon is stated explicitly to have occurred in the month Sivan, whereas the eclipse adopted occurred in Tammuz or later;

that the eclipse at Nineveh is not recorded as being total, as assumed without authority by Mr. Cowell, and so may have been only a large eclipse;

that a total eclipse may be found to represent that at Thasos on any system of data, that it is valueless as evidence of the accuracy of any system;

that the eclipse at Athens, though annular according to Mr. Cowell's data, is only recorded as having been very large, whilst it is represented just as well by other systems of data as by that adopted by him; and

that the eclipse of Utica has not been considered, as its epoch is so late that it cannot be regarded as of any value.

Taking these considerations into account it will be seen that the fact that these five eclipses selected by Mr. Cowell are rendered total by his data cannot be regarded as establishing the accuracy of the data adopted. Nor can it be urged that, though each of the preceding five eclipses may be represented just as well by other systems of data, yet Mr. Cowell's is the only system which will represent five eclipses, for the preceding examination shows that out of the twelve eclipses considered Hansen's theoretical values can be made to represent seven or possibly nine; that the strictly theoretical values of the secular accelerations will represent seven or eight; that the data derived exclusively

from the modern observations will represent six at least, but possibly eight; and that Mr. Cowell's data with some slight amendment may be made to represent as many as ten eclipses. The mere fact that a system of data represents a certain number of rather vaguely defined eclipses cannot be regarded as establishing anything.

In truth, the results which have been given show that unless it can be established that an eclipse was to all intents total at a specified place within a narrow definite period of years, it can be of small use as a criterion of the true values of the mean motions and secular accelerations. Of those in the preceding list there is but one possessing these requirements, and that is the eclipse of Larissa, though possibly the eclipse of Babylon may prove to be another.

In the memoir, in addition to the series of eclipses which has been considered in the preceding, there was also taken into account a series of twelve eclipses of the Sun, observed during the Chow dynasty in China, and presumably observed from the ancient capital of Heeng-Yang, in Shensee, where there still exists the remains of a very ancient observatory. It is possible, however, that in some cases the place of observation may have been the neighboring city of Chang-gan, which was the residence of some of the emperors during this period. Some of these eclipses are expressly recorded as total; and all seem to have been very large eclipses, if not at least annular. In each case the exact date of the eclipse is definitely fixed by the record, so that there is no uncertainty in this respect.

The eclipses are:—

						A	B	C	Cowell.
						°	°	°	°
XIII.	−497	Sept.	22	Annular	$\Delta\phi =$	− 4.2	= +3.6	= +1.8	= − 4.2
XIV.	−523	April	18	Annular		+ 8.3	−3.6	+0.0	− 5.4
XV.	−545	Oct.	3	Total		− 6.0	+4.2	+2.9	+ 6.8
XVI.	−548	June	19	Total		+ 4.2	+3.4	+3.3	− 0.2
XVII.	−549	Jan.	5	Annular		+13.2	+1.5	+6.4	+11.7
XVIII.	−574	May	9	Total		− 1.1	−1.9	−1.4	+ 2.2
XIX.	−600	Sept.	20	Total		−20.1	−2.3	−5.1	+ 2.0
XX.	−625	Feb.	3	Annular		+ 6.9	−0.3	+2.4	+ 8.6
XXI.	−663	Aug.	28	Total		−14.8	−3.4	−5.4	−12.2
XXII.	−667	Nov.	10	Annular		−12.3	−0.9	−4.7	−11.7
XXIII.	−668	May	27	Annular		− 3.5	−7.3	−5.5	+ 0.3
XXIV.	−708	July	17	Total		−19.9	−4.2	−5.8	− 3.0

There are several other eclipses during this period recorded as having occurred, whose place of observation is too uncertain to render them of value.

Use was also made of four more recent eclipses, recorded in more indefinite language, only the year and season being stated, but all explicitly described as total. These are the eclipses:—

XXV.	−180	Mar.	4	Total	$\Delta\phi = +1.6$	$= -3.5$	$= -2.1$	$= +0.9$
XXVI.	−187	July	17	Total	−8.3	+ 1.1	− 1.0	+ 1.9
XXVII.	−299	July	26	Total	−2.9	− 6.9	− 5.9	− 3.3
XXVIII.	−381	July	13	Total	−6.0	−13.8	−11.2	−15.6

This last eclipse is discordant on all systems of data, and could only have been total in Mongolia.

It will be seen that out of these sixteen eclipses observed in China, by regarding those for which $\Delta\phi$ is less than $2\frac{1}{2}°$ as total or annular, and those for which $\Delta\phi$ lies between $2\frac{1}{2}$ and $6°$ as so large and conspicuous as to be practically total, the number in the case of each of the four sets of data being considered is

	A	B	C	Cowell
Total or annular	2	6	6	6
Very large	5	7	8	4
Discordant	5	1	1	1

Practically the last three systems all serve to represent these Chinese eclipses as well as could be anticipated, and show the caution that must be employed in drawing deductions from such a circumstance.

In concluding this examination it must be pointed out that the preceding considerations do not invalidate Mr. Cowell's conclusion that the Moon's argument of latitude F possesses a secular acceleration of about +4″.4 per century; they show that the eclipses adduced by Mr. Cowell do not suffice to establish it as he supposed, and are quite consistent with systems of data very different from that adopted by him, and which do not involve the difficulties inseparable from his. But it must be distinctly understood that this is all. In many respects the preceding examination of the ancient eclipses strengthens Mr. Cowell's view, for it shows that his data serve to represent other eclipses besides those considered by him, and in particular that they serve to represent the eclipse of Larissa, the most critically important of them all. Indications of the existence of such a secular term, though smaller in amount, have been found cropping up repeatedly in the discussion of the early observations; but it is very difficult to differentiate such a secular term from the very similar effects which would be produced by inequalities of very long period in the complete expression for the Moon's latitude, and there is some reason for supposing these to exist.

A much wider question is raised by Mr. Cowell in his second paper, that the apparent secular acceleration of +4″.4 in the angular distance of the Moon from its node really arises from the existence of a secular acceleration of +4″.1 in the mean longitude of the Earth.

Assuming that the ancient eclipses of the Sun show that there exist a secular acceleration of +4″.4 in the angular distance of the Moon from the node and a secular acceleration of +6″.8 in the angular distance of the Moon from the Sun, Mr. Cowell points out that this can be represented by supposing the secular acceleration of the Moon's node to have the theoretical value of +6″.5, and assigning a secular acceleration of 6″.8+4″.1=10″.9 to the mean longitude of the Moon, and of +4″.1 to the apparent mean longitude of the Sun.

The effect of this change of origin of the secular acceleration leaves unchanged the epoch of conjunction of the mean longitudes of the Sun and Moon, and does not alter the values of either D=(L—L′) or F=(L—Ω); hence Mr. Cowell concludes that it leaves unchanged the figures of his eclipse calculations, except perhaps a small change of less than 20″ in the correction for parallax, which he regards as quite unimportant.*

But it will be seen that this new hypothesis as to the origin of the correction required by the Moon's argument of latitude removes one theoretical difficulty only at the expense of restoring another; for though the assumed secular acceleration of the Moon's node is brought into accord with theory, it is only at the cost of reinstating the discordance between 6″.0, the theoretical value of the secular acceleration in mean longitude, and that of 10″.9, the value necessitated by Mr. Cowell's new hypothesis. It is true that such a discordance conceivably might arise from tides in the body of the Earth, regarded as a thin rigid shell covering a viscous fluid interior or in an ocean entirely covering the surface of the Earth, though not from tides in smaller oceans having the physical configuration of those actually existing on the terrestrial surface; but there is no real evidence in support of a tidal retardation in the rotation of the Earth of a nature which could be held to account for a material discordance between the observed value of the secular acceleration of the Moon's mean

* This is an oversight of Mr. Cowell's. It is true that neither D nor F is altered, but both g and g' are changed by quantities which may exceed a degree of arc. Hence both V and V′ and their difference V—V′ may be changed by considerable quantities, possibly amounting to several hundreds of seconds of arc in the case of the earlier eclipses; whilst U will also be altered though to a smaller degree. Hence Mr. Cowell's eclipse calculations will no longer apply, and must be revised to meet the effects of the changed hypotheses. In the case of the five particular eclipses considered by Mr. Cowell it is probable that small alterations in his data will suffice to bring them into accord with the changed conditions, and so leave his calculations unaffected.

longitude and that derived by theory from the diminution in the eccentricity of the Earth's orbit.

The effect of this amended hypothesis for bringing the lunar tables into accord with the ancient eclipses by assuming the existence of a considerable secular acceleration in the motion of the Earth from the effects of a resisting medium in space proceeds far beyond the effect on the eclipses, but, except in respect of its effects on the observations of the transit of *Mercury*, these have not been considered by Mr. Cowell. It is not proposed, however, to discuss the matter beyond its effects on the apparent longitudes of the Sun and Moon, though these form a very small portion of the difficulties which would have to be overcome in reconciling with observation the effects due to this new hypothesis of Mr. Cowell's. The assumed secular retardation cannot be supposed to be confined merely to the Earth; so the assumed law of resistance in space must be such that, despite the great physical difference between the different planets, the apparent secular accelerations of the other planets would differ so slightly from the apparent secular acceleration of the Earth that no appreciable signs of the difference would be apparent. The more important cases would be those of *Venus* and *Mars*, whose observed secular variations are closely in accord with those derived from theory, and Mr. Cowell would have some difficulty in finding a law of resistance in space which would leave the relative motions of the three planets unaffected. The effects of the resisting medium would extend, of course, to the eccentricities as well as to the mean distances.

Restricting the consideration to the effects on the mean longitudes of the Sun and Moon, assuming 1900 as the epoch, the effect of the new secular term would be to increase the tabular longitudes by a second of arc, in 1850, so it will be necessary to increase the secular mean motions by some two seconds of arc, in order to bring the new tabular places into the same accord with observation as exists with the present tables as revised. The effect will be to increase the tabular longitudes of the Sun and Moon at different epochs by the quantities given in Column I of the table which follows. But it will be seen that this leaves discordances of over 6″ between Bradley's observations of 1750-60 and the tables as altered, discordances far greater than are admissible; hence to bring these earlier observations into accord with the changed tables a still further increase must be made in the secular mean motion, with the consequence that if the ancient eclipses are still to be represented, a further increase must also

be made in the value of the new secular acceleration. Adopting +5″.5 for the centennial increase in the mean longitude and +4″.33 for the coefficient of the new secular term, the tabular places of the Sun and Moon at different epochs will be changed by the quantities shown in Column II. For comparison, the columns headed "Sun" and "Moon" show the outstanding discordances between the observed and latest revised tabular places of the Sun and Moon, and the columns "Sun+II" and "Moon +II" the residuals which will remain outstanding when compared with tables modified by the quantities given under Column II.

Epoch	I.	II.	Sun.	Sun+II.	Moon	Moon+II.
	″	″	″	″	″	″
1900	+ .00	+ .00	+ .20	+ .20	+ .55	+ .55
1880	− .24	− .93	− .07	−1.00	+ .12	− .81
1860	− .14	− 1.51	− .41	−1.92	− .04	− 1.55
1840	+ .28	− 1.75	− .45	−2.20	− .21	− 1.96
1820	+ 1.02	− 1.63	+1.11	− .52	+ .52	− 1.11
1800	+ 2.10	− 1.17	− .72	−1.89	− .75	− 1.92
1780	+ 3.50	− .37	− .95	−1.32	+ .79	+ .42
1760	+ 5.24	+ .78	+ .22	+1.00	−1.70	− .92
1740	+ 7.30	+ 2.28	+ .30	+2.58	−1.94	+ .34
1720	+ 9.68	+ 4.12	...	...	− .13	+ 3.99
1700	+12.44	+ 6.65	...	...	− .39	+ 6.26
1680	+15.44	+ 8.85	...	...	+1.91	+10.74
1660	+18.81	+11.74	...	...	+ .98	+12.72

The resulting discordances between the tabular and observed places of the Moon between 1740 and 1900 could be eliminated by an increase in the assumed coefficients of the terms of very long period arising from the perturbations by the planets, but it is doubtful if the very large discordances between the observed and tabular times of the numerous occultations of stars observed between 1680 and 1730 could be similarly eliminated. But there is no such means of removing the discordances which the change would introduce between the observed and tabular places of the Sun during the period 1750-1880, and these discordances are far greater than can be ascribed to the outstanding errors of observation.

ASTRONOMICAL PHENOMENA FOR THE YEAR 1907.

ECLIPSES.

There will be four eclipses during the year, two of the Sun and two of the Moon. None of them are of much importance.

1. *A Total Eclipse of the Sun*, January 13, invisible in the United States, may be observed as a partial eclipse throughout the greater part of Asia. The path of totality passes from Russia at sunrise, across almost inaccessible portions of central Asia to the eastern part of Siberia at sunset.

ELEMENTS OF THE ECLIPSE.

Greenwich mean time of conjunction in right ascension January 13, $18^h\ 12^m\ 00^s.7$.

	h	m	s		s	s
Sun, and Moon's R.A.	19	39	04.37	Hourly motions	10.80 and	159.95
Sun's declination	−21°	29′	52″.5	Hourly motion	+ 0′	25″.5
Moon's declination	−20	37	23 .6	Hourly motion	+ 2	52 .0
Sun's equa. hor. parallax			8 .9	Sun's true semidiam.	16	15 .6
Moon's equa. hor. parallax	60	50	.4	Moon's true semidiam.	16	33 .9

CIRCUMSTANCES OF THE ECLIPSE.

	Greenwich Mean Time		Longitude from Greenwich		Latitude	
	h	m	°	′	°	′
Eclipse begins January 13	15	53.0	46	00.8 E	27	55.0 N
Central eclipse begins	17	13.5	42	18.8 E	50	25.8 N
Central eclipse at local noon	18	12.0	89	12.1 E	38	40.3 N
Central eclipse ends	18	57.8	130	49.3 E	56	45.2 N
Eclipse ends	20	18.4	131	28.9 E	35	12.1 N

2. *A Partial Eclipse of the Moon* January 29 will be partly visible in the United States, the Moon setting eclipsed as seen from the greater part of the country. The beginning will be visible generally in North America, the Pacific Ocean, central and eastern Asia, and Australia; the end visible in northwest North America, the Pacific Ocean, Asia, Australia, central and eastern Europe.

ELEMENTS OF THE ECLIPSE.

Greenwich mean time of opposition in right ascension, January 29, $1^h\ 26^m\ 25^s.0$.

	h	m	s			s
Sun's right ascension	20	43	44.84	Hourly motion		10.32
Moon's right ascension	8	43	44.84	Hourly motion		128.18
Sun's declination	−18°	08′	35″.6	Hourly motion	+ 0′	39″.7
Moon's declination	+18	42	13 .1	Hourly motion	− 5	16 .3
Sun's equa. hor. parallax			8 .9	Sun's true semidiam.	16	14 .2
Moon's equa. hor. parallax		55	02 .1	Moon's true semidiam.	14	59 .1

TIMES OF THE PHASES.

	Greenwich Mean Time			Central Standard Time		
		h	m		h	m
Moon enters penumbra	Jan. 28	22	45.9	Jan. 28	16	45.9
Moon enters shadow	29	0	06.3		18	06.3
Middle of the eclipse	29	1	39.1		19	39.1
Moon leaves shadow	29	3	09.9		21	09.9
Moon leaves penumbra	29	4	30.2		22	30.2

Magnitude of the eclipse = 0.711 (Moon's diameter = 1.0).

3. *An Annular Eclipse of the Sun* July 10 will not be visible in the United States. It will be visible as a partial eclipse in all of South America and parts of the Atlantic and Pacific Oceans and, just at sunset, on the west coast of South Africa. The path of annular eclipse passes across the center of South America.

ELEMENTS OF THE ECLIPSE.

Greenwich mean time of conjunction in right ascension July 10, $3^h\ 26^m\ 40^s.1$.

	h	m	s		s	s
Sun's and Moon's R. A.	7	14	35.93	Hourly motions	10.23 and	127.42
Sun's declination	+22°	20′	33″.9	Hourly motion	— 0′	18″.2
Moon's declination	+21	46	33 .8	Hourly motion	— 1	03 .5
Sun's equa. hor. parallax			8 .7	Sun's true semidiam.	15	43 .9
Moon's equa. hor. parallax	53	57	.8	Moon's true semidiam.	14	41 .6

CIRCUMSTANCES OF THE ECLIPSE.

	Greenwich Mean Time.			Longitude from Greenwich			Latitude		
	h	m		°	′		°	′	
Eclipse begins	July 10	0	34.8	88	32.8	W	20	36.5	S
Central eclipse begins		1	52.8	100	30.6	W	34	32.4	S
Central eclipse at local noon		3	26.7	50	25.1	W	16	57.5	S
Central eclipse ends		4	56.4	1	07.0	W	37	21.2	S
Eclipse ends		6	14.4	12	38.4	W	23	31.4	S

4. *A Partial Eclipse of the Moon* July 24 will be visible in the United States. The beginning will be visible generally in central and western Europe, Africa, South America, and North America except the northwest portion. The end may be observed generally in western Africa, South America and North America except the peninsula of Alaska.

ELEMENTS OF THE ECLIPSE.

Greenwich mean time of opposition in right ascension, July 24, $16^h\ 13^m\ 36^s.8$.

	h	m	s		s	s
Sun's right ascension	8	13	11.23	Hourly motion		9.91
Moon's right ascension	20	13	11.23	Hourly motion		160.79
Sun's declination	+19°	55	44″.7	Hourly motion	— 0′	31″.3
Moon's declination	+20	38	27 .1	Hourly motion	+ 4	52 .1
Sun's equa. hor. parallax			8 .7	Sun's true semidiam.	15	44 .8
Moon's equa. hor. parallax		61	10 .8	Moon's true semidiam.	17	39 .5

TIME OF THE PHASES.

	Greenwich Mean Time.				Central Standard Time.			
			h	m			h	m
Moon enters penumbra	July	24	13	58.7	July	24	7	58.7
Moon enters shadow			15	03.7			9	03.7
Middle of eclipse			16	22.4			10	22.4
Moon leaves shadow			17	41.1			11	41.1
Moon leaves penumbra			18	46.2			12	46.2

Magnitude of Eclipse = 0.620 (Moon's diameter = 1.0).

THE PLANETS.

The apparent courses of the planets among the stars during the year 1907 are shown upon the charts Figures 1 and 2. *Mercury* begins the year on the west side of the Sun, between the constellations Scorpio and Sagittarius, moves eastward on the farther side of the Sun until March, then while coming around between the Earth and the Sun describes the large loop shown on the chart in the constellations Aquarius and Pisces. In July and August another loop is formed in Cancer, and a third in Libra in November. All these loops are pro-

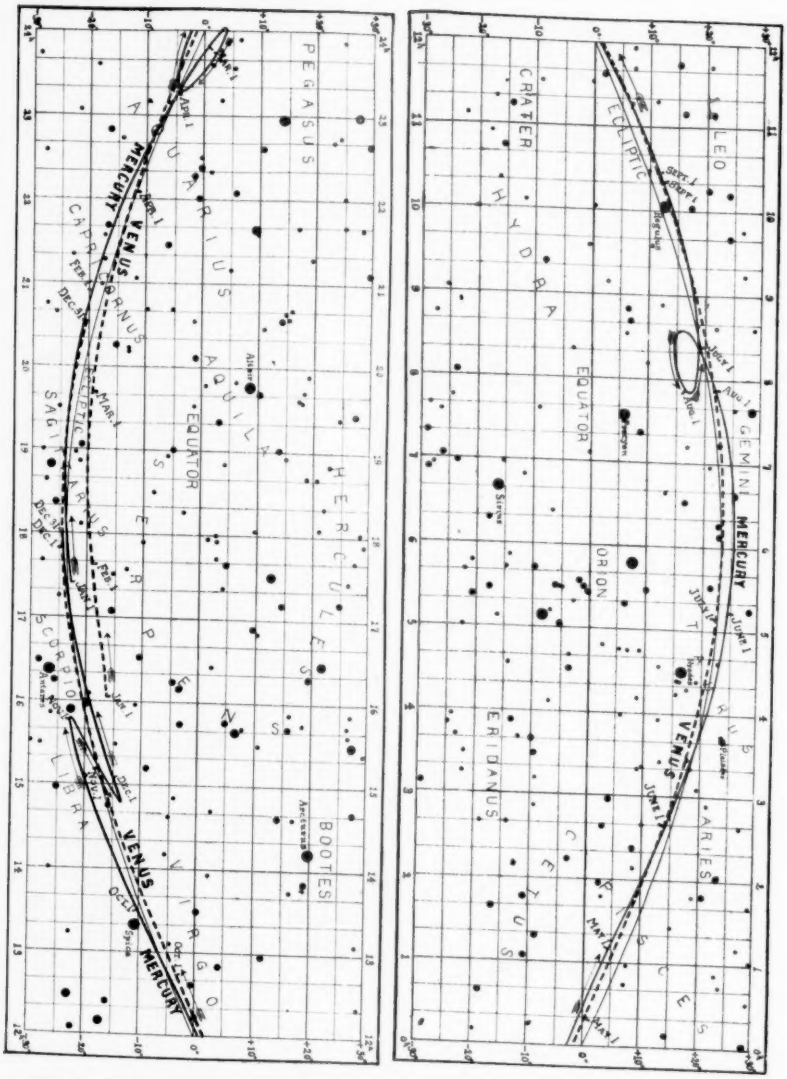


FIG. 1. THE APPARENT PATHS OF THE PLANETS MERCURY AND VENUS DURING THE YEAR 1907.

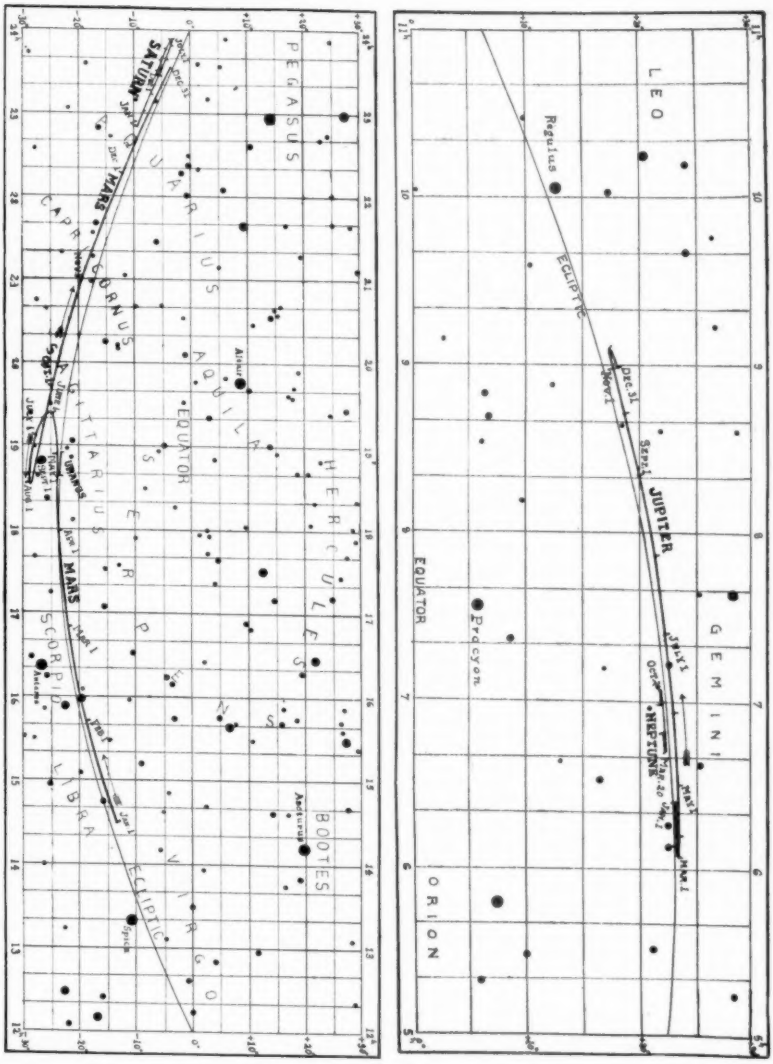
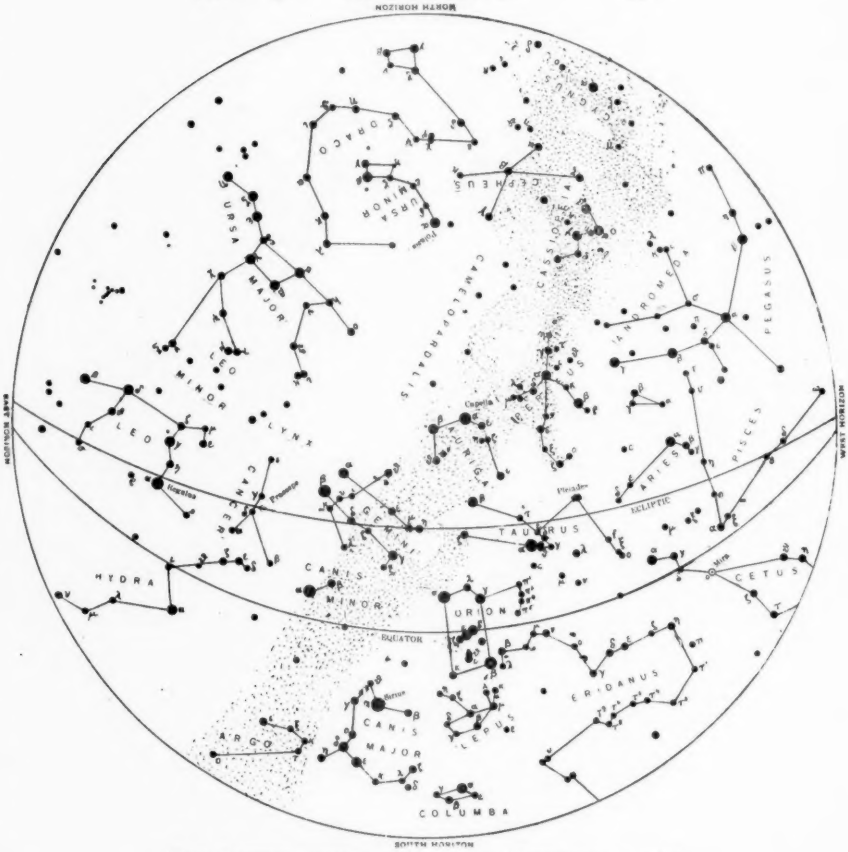


FIG. 2. THE APPARENT PATHS OF THE PLANETS MARS, JUPITER, SATURN AND URANUS DURING THE YEAR 1907.

duced by the retrograde movement of Mercury when it passes between the Earth and the Sun. The best time to look for Mercury this year will be at the time of greatest eastern elongation about March 1. The planet will then be north of the ecliptic and so much farther north than the Sun in declination that it will set nearly an hour and three-quarters later than the Sun. It will also be then at nearly its maximum brightness being near perihelion. The following table gives the times when Mercury will be at greatest elongation during the year, together with its angular distance from the Sun and its comparative brightness at those times.

		Elongation.	Distance	Brightness.
March	1	East	18° 10′	65
April	14	West	27 36	33
June	26	East	25 29	34
Aug.	12	West	18 51	52
Oct.	22	East	24 20	37
Nov.	30	West	20 20	55



THE CONSTELLATIONS AT 9:00 P. M., FEBRUARY 1, 1907.

Venus will follow the path indicated by the dotted line on the chart, Figure 1, beginning in Scorpio and ending in Capricornus after having passed through Scorpio the second time. Venus will be morning star during the first two thirds of the year and will be at greatest brilliancy on January 4. She will come to superior conjunction on September 14.

Mars, as shown on the chart, Figure 2, begins his course in Libra, moves southeast along the ecliptic until June, when he retrogrades in Sagittarius forming a closed loop in his path, and after that moves northeast through Capricornus and Aquarius, coming to conjunction with Saturn at the end of the year. Mars will be at opposition July 6, but will then be so far south that the conditions will be very unfavorable for observations at northern observatories. In the southern hemisphere on the contrary the conditions will be extremely favorable. The planet at opposition will be only 38,000,000 miles from the Earth, its apparent diameter will be 24″ so that its surface markings should show up very plainly.

Jupiter's course lies through Gemini and Cancer. His motion is retrograde during January and February, then direct until December and retrograde during the last month. Jupiter does not come to opposition this year, having passed that position just a few days ago and not reaching it again until January 29, 1908.

Saturn begins the year with direct movement in Aquarius and continues to move northeast until July 1, then retrogrades until December, and again turns toward the northeast for the remainder of the year. This year the rings of Saturn will be turned edgewise to us and the Earth will pass twice through their plane, so that we shall have the opportunity to study their thickness. The dates when the Earth will be exactly in the plane of the rings are April 12 and October 4. The Sun will be in the plane of the rings, so that neither side will be illuminated on July 25. As Saturn will be in conjunction with the Sun on March 8 the disappearance of the rings in April will be difficult to observe, but in July and October the conditions will be much more favorable, the planet being at opposition September 17. The satellites during this year will appear to move back and forth in very narrow ellipses tilting, first one way, then the other, then back again, as the Earth passes through the planes. The following table gives the dates when the Earth passes through the planes of the several satellite orbits:

	The Earth passes through the plane of the orbit	
	North to South	South to North
Mimas	May 19	...
Enceladus	April 12	Oct. 4
Tethys	May 3	Sept. 15
Dione	April 12	Oct. 4
Rhea	April 14	Sept. 30
Titan	April 15	Sept. 29
Hyperion	April 29	Sept. 12
Iapetus	...	...

Uranus describes a short course in Sagittarius very close to the ecliptic, going over that course three times during the year, first direct, then retrograde, then direct again. Uranus will be in conjunction with Mars on May 1.

Neptune also describes only a short path in the sky, in the constellation Gemini, retrograding for nearly three months, then advancing for six months, then again retrograding for the remainder of the year. Neptune will be in conjunction with Jupiter on May 21, the two planets being then just one degree apart in declination.

TRANSIT OF MERCURY.

A transit of Mercury over the Sun's disk will occur on the morning of November 14, which will be partly visible in the United States, the Sun rising with Mercury on its disk. The ingress of the planet upon the Sun's disk will be visible generally in Europe, Africa, western and central Asia, western Australia and

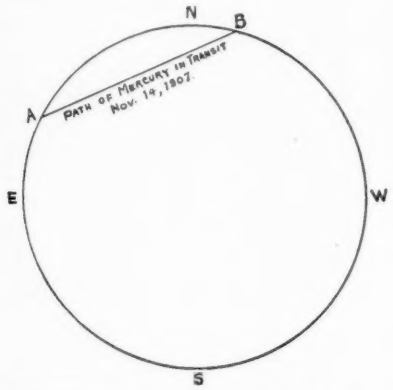


FIG. 3. THE TRANSIT OF MERCURY ACROSS THE DISK OF THE SUN ON THE MORNING OF NOVEMBER 14, 1907.

South America: the egress in Europe except the northeast portion, Africa, western Asia, South America and North America except the northwest portion.

The following data are given in the *American Ephemeris* for 1907:

ELEMENTS OF THE TRANSIT.

Greenwich mean time of conjunction in right ascension, November 14^d $1^h\ 02^m\ 27^s$.

	h	m	s					
Sun's and Mercury's R. A.	15	14	18.58	Hourly motions	+10.22	and	−12.67	
Sun's declination	−18°	01′	17″.0	Hourly motion			− 0′	39″.8
Mercury's declination	−17	47	19 .6	Hourly motion			+ 1	42 .7
Sun's equa. hor. parallax			8 .90	True semidiam.			16	10 .15
Mercury's equa. hor. parallax			13 .00	True semidiam.				4 .94

TIMES OF GEOCENTRIC PHASES.

	Greenwich Mean Time.				Central Standard Time			
		h	m	s		h	m	s
Ingress, exterior contact	Nov. 13	22	23	39.9	Nov. 13	16	23	39.9
Ingress, interior contact	13	22	26	19.3		16	26	19.3
Least distance of centers 12′ 38″.4	14	0	06	47.7		18	06	47.7
Egress, interior contact	14	1	47	18.3		19	47	18.3
Egress, exterior contact	14	1	49	57.8		19	49	57.8

Angles of position from the North point of the Sun's Disk.

Ingress, exterior contact	62° 30′	East
Ingress, interior contact	61 46	East
Egress, interior contact	14 39	West
Egress, exterior contact	15 23	West

The Greenwich mean times of the four contacts for any point on the surface of the Earth may be computed from the four following formulæ, in which ρ denotes the radius of the Earth at that point, ϕ' the geocentric north latitude and

λ the longitude *west* from Greenwich. The numbers in brackets are the logarithms of the respective coefficients.

	h	m	s					°	′	
Ing. ext. =	22	23	39.9	− [1.4665] $\rho \sin \phi'$	− [1.7723] $\rho \cos \phi' \cos$	(	258	02.7	− λ)
Ing. int. =	22	26	19.3	− [1.4837] $\rho \sin \phi'$	− [1.7767] $\rho \cos \phi' \cos$	(	258	59.7	− λ)
Egr. ext. =	1	47	18.3	+ [1.7922] $\rho \sin \phi'$	+ [1.4077] $\rho \cos \phi' \cos$	(	72	18.5	− λ)
Egr. ext. =	1	49	57.8	+ [1.7838] $\rho \sin \phi'$	+ [1.4091] $\rho \cos \phi' \cos$	(	74	26.7	− λ)

PHASES OF THE MOON.

New Moon				First Quarter				Full Moon				Last Quarter			
1907		h	m			h	m			h	m			h	m
												Jan.	6	21	39.2
Jan.	13	12	48.7	Jan.	20	15	33.7	Jan.	28	20	36.8	Feb.	5	7	43.5
Feb.	12	0	34.6	Feb.	19	11	26.6	Feb.	2[illegible]	13	14.5	Mar.	6	15	33.5
Mar.	13	12	56.5	Mar.	21	8	01.5	Mar.	29	2	36.1	Apr.	4	22	12.2
Apr.	12	1	57.5	Apr.	20	3	29 7	Apr.	27	12	56.5	May	4	4	45.2
May	11	15	51.0	May	19	20	19.2	May	26	21	09 5	June	2	12	11.3
June	10	6	41.6	June	18	9	46.7	June	25	4	18.7	July	1	21	25.6
July	9	22	08.8	July	17	20	03.3	July	24	11	21.2	July	31	9	17.2
Aug.	8	13	28.1	Aug.	16	3	57.2	Aug.	22	19	06.8	Aug.	30	0	19.6
Sept.	7	3	55.7	Sept.	14	10	31.8	Sept.	21	4	25.4	Sept.	28	18	28.8
Oct.	6	17	12.3	Oct.	13	16	53.7	Oct.	20	16	08.2	Oct.	28	14	43.2
Nov.	5	5	30.6	Nov.	12	0	06.1	Nov.	19	6	56.0	Nov.	27	11	12.7
Dec.	4	17	14.1	Dec.	11	9	07.7	Dec.	19	0	46.8	Dec.	27	6	02.2

OCCULTATIONS.

The list of Occultations given by the *American Ephemeris* as visible at Washington during this year numbers 89. We plan to give the lists for each month in POPULAR ASTRONOMY one month ahead of time so that our readers may have ample notice of each. The list for February is as follows.

OCCULTATIONS VISIBLE AT WASHINGTON.

			IMMERSION.			EMERSION.			
Date 1907	Star's Name	Magnitude.	Washington M.T. h	m	Angle f'm N. °	Washington M.T. h	m	Angle f'm N. °	Duration. h	m
Feb. 22	15 Geminorum	6.5	10	18	43	11	12	323	0	54
22	16 Geminorum	6.2	10	17	117	11	33	249	1	16
23	5.6 Geminorum	5.2	11	45	91	13	00	290	1	15
23	61 Geminorum	5.8	14	34	80	15	29	300	0	55
24	BD.+20°, 1976	6.3	3	44	34	4	20	323	0	36
30	*l* Leonis	5.3	12	22	69	13	17	347	0	55

COMETS.

The last two comets discovered in 1906, *g* (Thiele), and *h* (Metcalf) will be visible for some time during 1907 but are both past perihelion and growing fainter.

Of periodic comets expected to return to perihelion there are possibly three.

1. Swift's comet, 1889 VI, was due about December 24, 1906 if the period 8.534 years is correct and may possibly be found in January.

2. Edward Swift's comet 1894 IV, which is possibly identical with DeVico's comet, according to Sear's elements is due at perihelion in July and may perhaps be found in June.

3. Giacobini's comet 1900 III will be at perihelion about September 1, and should be in quite favorable position to be rediscovered during the summer.

All of these comets were faint and not visible to the naked eye.

METEOR SHOWERS.

The following list of radiant points of meteoric showers is taken from a list

of 90 radiant points given by Mr. W. F. Denning in the *Companion to the Observatory* for 1906.

Date.	Radiant α	Radiant δ	Remarks
Jan. 2-3	230°	+ 53	Swift: long paths.
Apr. 20-22	271	+ 33	Swift.
May 1-6	338	− 2	Swift; streaks.
July 28	339	− 11	Slow; long.
Aug. 10-12	45	+ 57	Swift; streaks.
Oct. 18-20	92	+ 15	Swift; streaks.
Nov. 14-16	150	+ 22	Swift; streaks.
Nov. 17-23	25	+ 43	Very slow; strains.
Dec. 10-12	108	+ 33	Swift: short.

The Perseids, with a maximum on August 11, are visible for a considerable period and their radiant exhibits a motion, to the E. N E. among the stars of about 1° per day. Its position for July 19 should be α 19°, δ + 50°, and on Aug. 16, α 53°, δ + 58°.

Phenomena of the Satellites of Jupiter.

1907 Central Standard Time, reckoning from noon.

Feb.	1	6h 28m	III Oc. Re.	Feb.	12	6h 24m	I Sh. In.
		6 51	III Ec. Dis.			7 15	II Ec. Re.
		6 58	IV Tr. In.			7 40	I Tr. Eg.
		8 41	IV Tr. Eg.			8 41	I Sh. Eg.
		9 48	III Ec. Re.		13	5 52	I Ec. Re.
		10 56	II Oc. Dis.		15	10 31	III Oc. Dis.
		14 29	IV Sh. In.			13 33	III Oc. Re.
		14 42	I Tr. In.		17	10 06	II Tr. In.
		15 23	II Ec. Re.			12 19	II Sh. In.
		15 32	I Sh. In.			12 45	I Tr. In.
	2	11 52	I Oc. Dis.			12 56	II Tr. Eg.
		14 59	I Ec. Re.			13 50	I Sh. In.
	3	5 18	II Tr. In.		18	8 28	IV Sh. In.
		7 3	II Sh. In.			9 57	I Oc. Dis.
		8 8	II Tr. Eg.			10 55	IV Sh. Eg.
		9 8	I Tr. In.			13 19	I Ec. Re.
		9 55	II Sh. Eg.		19	7 12	I Tr. In.
		10 0	I Sh. In.			8 06	III Sh. In.
		11 25	I Tr. Eg.			8 19	I Sh. In.
		12 18	I Sh. Eg.			9 29	I Tr. Eg.
	4	6 19	I Oc. Dis.			9 50	II Ec. Re.
		9 28	I Ec. Re.			10 36	I Sh. Eg.
		5 52	I Tr. Eg.		20	7 48	I Ec. Re.
		6 46	I Sh. Eg.		24	12 34	II Tr. In.
	8	6 57	III Oc. Dis.		25	11 48	I Oc. Dis.
		9 58	III Oc. Re.		26	6 02	IV Oc. Dis.
		10 51	III Ec. Dis.			7 14	III Tr. Eg.
		13 16	II Oc. Dis.			7 17	II Oc. Dis.
		13 49	III Ec. Re.			8 01	IV Oc. Re.
	9	13 40	I Oc. Dis.			8 56	III Sh. In.
		14 01	IV Oc. Dis.			9 02	I Tr. In.
	10	7 41	II Tr. In.			10 13	I Sh In.
		9 41	II Sh. In.			11 19	I Tr. Eg.
		10 31	II Tr. Eg.			12 7	III Sh. Eg.
		10 56	I Tr. In.			12 26	II Ec. Re.
		11 55	I Sh. In.			12 31	I Sh. Eg.
		12 33	II Sh. Eg.		27	6 16	I Oc. Dis.
		13 13	I Tr. Eg.			9 43	I Ec. Re.
		14 12	I Sh. Eg.		28	5 47	I Tr. Eg.
	11	8 8	I Oc. Dis.			7 00	I Sh. Eg.
		11 23	I Ec. Re.			7 08	II Sh. Eg.
	12	5 23	I Tr. In.				

Note.—In., denotes ingress; Eg., egress; Dis., disappearance; Ec., eclipse; Oc., occultation; Tr., transit of the satellite; Sh., transit of the shadow.

COMET NOTES.

Elements and Ephemeris of Comet *g* 1906 (Thiele). From the telegraphed discovery position of this comet (November 10.50) and the observations secured with the 12-inch telescope of the Lick Observatory on the nights of November 17 and 21 we have derived the following set of parabolic elements. But one solution was made, the residuals being so small that it did not seem necessary to attempt a closer approximation.

ELEMENTS.

$T =$ 1906 November 21.14697 G. M. T.
$\omega = 84\ \ 54\ \ 48\ .3$
$\Omega = \ 8°\ 33'\ 48''.9$ 1906.0
$i = 56\ \ 27\ \ 41\ .5$
$\log q = 0.084400$

Residuals (O—C).
$\Delta\lambda' \cos\beta'$, $+4''.0$; $\Delta\beta'$, $-0''.7$

CONSTANTS FOR THE EQUATOR OF 1906.0.

$x = r\,[9.746181] \sin(179°\ 24'\ 41''.2 + v)$
$y = r\,[9.981243] \sin(115\ \ 59\ \ 13\ .7 + v)$
$z = r\,[9.943820] \sin(\ 35\ \ 22\ \ 51\ .0 + v)$

CONSTANTS FOR THE EQUATOR OF 1907.0.

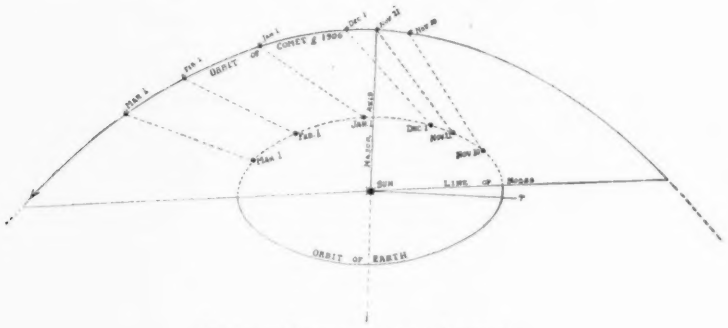
$x = r\,[9.746160] \sin(179\ \ 26\ \ 10\ .5 + v)$
$y = r\,[9.981268] \sin(115\ \ 59\ \ 37\ .9 + v)$
$z = r\,[9.943800] \sin(\ 35\ \ 22\ \ 58\ .2 + v)$

EPHEMERIS FOR GREENWICH MEAN MIDNIGHT.

1906		True α			True δ		$\log\Delta$	$\log r$	Brightness
		h	m	s	°	′			
Nov.	28.5	10	52	43	+36	15.7	9.7998	0.0863	1.49
	30.5	11	6	39	38	54.7			
Dec.	2.5		21	13	41	27.0	9.8043	0.0890	1.44
	4.5		36	24	43	50.6			
	6.5	11	52	9	46	4.4	9.8150	0.0927	1.35
	8.5	12	8	22	48	7.2			
	10.5		24	57	49	58.6	9.8309	0.0974	1.28
	12.5		41	46	51	38.2			
	14.5	12	58	41	53	6.1	9.8506	0.1030	1.09
	16.5	13	15	33	54	22.6			
	18.5		32	15	55	28.5	8.8727	0.1095	0.96
	20.5	13	48	36	56	24.6			
	22.5	14	4	31	57	11.8	9.8964	0.1167	0.83
	24.5		19	52	57	51.3			
	26.5		34	35	58	23.9	9.9206	0.1246	0.72
	28.5	14	48	36	58	50.8			
	30.5	15	1	54	59	12.8	9.9447	0.1330	0.62
1907									
Jan.	1.5		14	28	56	30.9			
	3.5		26	17	59	45.9	9.9682	0.1419	0.53
	5.5		37	22	59	58.4			
	7.5		47	45	60	9.0	9.9910	0.1512	0.46
	9.5	15	57	26	60	18.2			
	11.5	16	6	27	60	26.5	0.0129	0.1608	0.40
	13.5		14	51	60	34.2			
	15.5		22	39	60	41.9	0.0336	0.1707	0.34
	17.5		29	52	60	49.5			
	19.5	16	36	34	+60	58.0	0.0532	0.1807	0.30

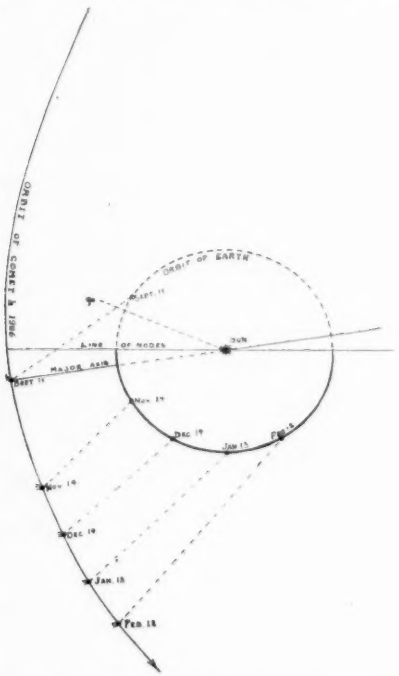
R. G. AITKEN,
E. A. FATH.

Lick Observatory Bulletin No. 103.
November 24, 1906.



ORBIT OF COMET *g* 1906 (THIELE).

Diagrams of the Orbits of Comets *g* 1906 (Thiele) and *h* 1906 (Metcalf).—The two accompanying diagrams will place before the eye of the reader the relative positions of the Earth, Sun and comets at the present time.



ORBIT OF COMET *h* 1906 (METCALF).

The diagram for Thiele's comet was prepared from the elements, elsewhere given, computed by Messrs Aitken and Fath. The comet's orbit is a parabola and is

represented as in the plane of the paper while the Earth's orbit is inclined to the plane of the paper by an angle of 56°. It is evident that the comet came up from below the ecliptic about six months ago, but it was not discovered until a few days before it reached perihelion. It is now receding from both the Earth and the Sun so that there is no hope of its becoming brighter. Its movement during December has been quite rapid and it has passed through the tail of Ursa Major into Draco. One may find it with the aid of a telescope on January 2 near the star ι Draconis and on January 18 near η Draconis.

Metcalf's comet is also past perihelion and we are receding from it. In the diagram the Earths orbit is supposed to be tilted about 20° to the plane of the paper the dotted portion being below the plane. This comet is so faint and small that it can be seen with extreme difficulty with a small telescope. Elements which have come to hand since this diagram was prepared, computed by Crawford at Berkeley, California, indicate that the comet may be moving in an ellipse with a period of a little less than seven years. If so it adds another to the Jupiter family of comets.

Elliptic Elements of Comet *h* 1906 (Metcalf).—A telegram has been received at this Observatory from Professor A. O. Leuschner at Berkeley, California, stating that the following elliptic elements and ephemeris of Metcalf's comet have been computed by Crawford from observations on November 17, 25 and December 5.

ELEMENTS.

Time of passing perihelion	$= T =$	1906 Oct. $16^d.45$ G. M. T.
Perihelion minus node	$= \omega =$	205° 07′
Longitude of node	$= \Omega =$	193° 12′
Inclination	$= i =$	14° 04′
Perihelion distance	$= q =$	1.630
Eccentricity	$= e =$	0.5501
Period	$= P =$	6.89 yrs.

EPHEMERIS.

G.M.T.	R. A. h m s	Dec. ° ′	Light.
1906 Dec. 12.5	3 59 12	−5 32	0.69
16.5	3 59 20	−5 26	
20.5	3 59 48	−5 13	
Dec. 24.5	4 00 41	−4 54	0.53

Astronomical Bulletin No. 271.
Harvard College Observatory,
Cambridge, Mass.
December 11, 1906.

Elements of Comet *h* 1906 (Metcalf). A telegram has been received at this Observatory from Rear Admiral Asa Walker, Supt. U. S. Naval Observatory, stating that the following elements and ephemeris of Metcalf's comet have been computed by Miss Eleanor A. Lamson from observations on Nov. 17, 21, 25.

ELEMENTS.

Time of passing perihelion	$= T =$	1906 Sept. $15^d.15$ G.M.T.
Perihelion minus node	$= \omega =$	187° 40′
Longitude of node	$= \Omega =$	201 06
Inclination	$= i =$	21 22
Perihelion distance	$= q =$	2.003

EPHEMERIS.

G. M. T.	R. A.	Dec.	Light.
d	h m s	° ′	
1906 Dec. 6.5	3 59 40	−5 44	1.00
10.5	3 59 06	−6 00	
14.5	3 58 46	−6 10	
Dec. 18.5	3 58 42	−6 14	0.79

Astronomical Bulletin, No. 269.
Harvard College Observatory,
Cambridge, Mass.
December 4, 1906.

Errata.—In the December number of *Popular Astronomy* the designations of the two new comets were wrongly given. The one discovered by Thiele should be Comet *g* instead of Comet *f* 1906 and that discovered by Metcalf should be called Comet *h* 1906.

VARIABLE STARS.

Approximate Magnitudes of Variable Stars on Dec. 1, 1906.

[Communicated by the Director of Harvard College Observatory, Cambridge, Mass.]

Name.	R. A. 1900.	Decl. 1900.	Magn.	Name.	R. A. 1900.	Decl. 1900.	Magn.
	h m	° ′			h m	° ′	
X Androm.	0 10.8	+46 27	11.8*d*	X Camelop.	4 32.6	+74 56	8.5
T Androm.	17.2	+26 26	13.5*d*	V Tauri	46.2	+17 22	13.0*d*
T Cassiop.	17.8	+55 14	12.0*d*	R Orionis	53.6	+ 7 59	9.7 *i*
R Androm.	18.8	+38 1	13.5*d*	R Leporis	55.0	−14 57	9.5
S Ceti	19.0	− 9 53	13.0 *i*	T Leporis	5 0.6	−22 2	10·0
U Cassiop.	40.8	+47 43	10.7*d*	R Aurigae	9.2	+53 28	9.0*d*
V Androm.	44.6	+35 6	9.5*d*	S Aurigae	20.5	+34 4	6.3 *i*
RR Androm.	45.9	+33 50	11.8*d*	S Orionis	24.1	− 4 46	10.7*d*
W Cassiop.	49.0	+58 1	10.0*d*	T Orionis	30.9	− 5 32	11.5
U Androm.	1 9.8	+40 11	14.2*d*	S Camelop.	30.2	+68 45	8.5*d*
S Piscium	12.4	+ 8 24	11 0 *i*	RR Tauri	33.3	+26 19	11.7
S Cassiop.	12.3	+72 5	9.2*d*	U Aurigae	35.6	+31 59	11.5*d*
U Piscium	17.7	+12 21	12.0 *i*	U Orionis	49.9	+20 10	11.2*d*
R Piscium	25.5	+ 2 22	12.2*d*	V Camelop.	49.4	+74 30	13.5
RU Androm.	32.8	+38 10	14.3*d*	Z Aurigae	53.7	+53 18	12
Y Androm.	33.7	+38 50	8 8 *i*	V Monoc.	6 17.7	− 2 9	8.0
X Cassiop.	49.8	+58 46	9.7 *i*	R Monoc.	33.7	+ 8 49	11.5
U Persei	52.9	+54 20	10.3*d*	S Lyncis	35.9	+58 0	9.0 *i*
R Arietis	2 10.4	+24 35	9.5 *i*	W Monoc.	47.5	− 7 2	10.0
W Androm.	11.2	+43 50	13.0	X Monoc.	52.4	− 8 56	8.0
o Ceti	14.3	− 3 26	2.0 *i*	R Lyncis	53.0	+55 28	8.0*d*
S Persei	15.7	+58 8	9.7*d*	S Can. Min.	7 27.3	+ 8 32	7.8*d*
R Ceti	20.9	− 0 38	8.5 *i*	Z Puppis	38.3	+11 58	<12
U Ceti	28.9	+13 35	7.8*d*	RT Hydrae	8 24.7	− 5 59	7.5
R Trianguli	31.0	+33 50	8.7*d*	S Hydrae	48.4	+ 3 27	8.8*d*
T Arietis	42.8	+17 6	9.5*d*	T Hydrae	50.8	− 8 46	10.5
W Persei	43.2	+56 34	9.0 *i*	T Cancri	51.0	+20 14	9.0
U Arietis	3 5.5	+14 25	12.0 *i*	W Cancri	9 4.0	+25 39	9.0
Y Persei	20.9	+43 50	9.0*d*	R Leonis	42.2	+11 54	8.7*d*
R Persei	23 7	+35 20	13.2*d*	V Leonis	54.5	+21 44	10.0
Nov. Per. No.2	24.4	+43 34	13.0*d*	R Urs. Maj.	10 37.6	+69 18	8.5 *i*
T Tauri	4 16.2	+19 18	11.8*d*	W Leonis	48.4	+14 15	<12
R Tauri	22.8	+ 9 56	10.7*d*	S Leonis	11 5.8	+ 6 0	11.5
W Tauri	22.2	+15 49	11.8*d*	R Comae	59.1	+19 20	11.5*d*
T Camelop.	30.4	+65 57	10.0 *i*	R Corvi	12 14.4	−18 42	7.8

Approximate Magnitudes of Variable Stars on Dec. 1, 1906.

(Continued.)

Name.	R. A. 1900. h	m	Decl. 1900. °	′	Magn.	Name.	R.A. 1900. h	m	Decl. 1900. °	′	Magn.
T Urs. Maj.	12	31.8	+60	2	12.0*d*	Z Aquilae	20	9.8	− 6	27	13.5
R Virginis		33.4	+ 7	32	7.5 *i*	RS Cygni		9.8	+38	28	7.8 *i*
S Urs. Maj.		39.6	+61	38	7.8	R Delphini		10.1	+ 8	47	9.0*d*
RU Virginis		42.2	+ 4	42	11.5	RT Capric.		11.2	−21	38	7.0
U Virginis		46.0	+ 6	6	11.5*d*	SX Cygni		11.6	+30	46	14
R Can. Ven	13	44.6	+40	2	9.7	WX Cygni		14.8	+37	8	10.0 *i*
R Camelop.	14	25.1	+84	17	9.7*d*	V Sagittae		15.8	+20	47	12.0*d*
R Bootis		32.8	+27	10	9.3*d*	U Cygni		16.5	+47	35	6.8 *i*
S Coronae	15	17.3	+31	44	13.0	RW Cygni		25.2	+39	39	8.5*d*
S Urs. Min.		33.4	+78	58	9.0*d*	ST Cygni		29.9	+54	38	12.2*d*
R Coronae		44.4	+28	28	5.8	Y Delphini		36.8	+11	30	13.0*d*
RR Herculis	16	1.5	+50	46	9.0	S Delphini		38.5	+16	44	12.2
RU Herculis		6.0	+25	20	12.5 *i*	Y Aquarii		39.2	− 5	12	8.7
W Coronae		11.8	+38	3	10.0*d*	T Delphini		40.7	+16	2	13.5
W Herculis		31.7	+37	32	14.0*d*	V Aquarii		41.8	+ 2	4	8.7*d*
R Draconis		32.4	+66	58	8.0*d*	W Aquarii		41.2	− 4	27	12.0*d*
RT Herculis	17	6.8	+27	11	14.0	V Delphini		43.2	+18	58	<14
Z Ophiuchi		14.5	+ 1	37	8.7*d*	T Aquarii		44.7	− 5	31	8.0*d*
RS Herculis		17.5	+23	1	7.8	RZ Cygni		48.5	+46	59	11.8 *i*
T Draconis		54.8	+58	14	11.0	X Delphini		50.3	+17	16	12.0 *i*
RY Herculis		55.4	+19	29	8.0	UX Cygni		50.9	+30	2	<14
V Draconis		56 3	+54	53	12.8*d*	R Vulpeculae		59.9	+23	26	8.5 *i*
RW Herculis	18	1.7	+22	4	13.5	V Capric.	21	1.8	−24	19	10.5*d*
T Herculis		5.3	+31	0	13.5	TW Cygni		1.8	+29	0	<12.5
W Draconis		5.4	+65	56	8.5	X Cephei		3.6	+82	40	12.5 *i*
X Draconis		6.8	+66	8	<14	Z Capric.		5.0	−16	35	13.5*d*
W Lyrae		11.5	+36	38	9.0 *i*	R Equulei		8.4	+12	23	12.5 *i*
T Serpentis		23.9	+ 6	14	12.5	T Cephei		8.2	+68	5	10.0*d*
RZ Herculis		32.7	+25	58	8.5 *i*	T Capric.		16.5	−15	35	13.0*d*
X Ophiuchi		33.6	+ 8	44	8.7*d*	Y Capric.		28.9	−14	25	13.5
RY Lyrae		41.2	+34	34	<14	S Cephei		36.5	+78	10	9.0*d*
RW Lyrae		42.2	+43	32	<14	RU Cygni		37.3	+53	52	7.8
RX Lyrae		50.4	+32	42	13.8	SS Cygni		38.8	+43	8	9.0 *i*
Z Lyrae		56.0	+34	49	11.5	RR Pegasi		40.0	+24	33	13.5
RT Lyrae		57.8	+37	22	<12	V Pegasi		56.0	+ 5	38	12.3 *i*
R Aquilae	19	1.6	+ 8	5	8.0 *i*	U Aquarii		57.9	−17	6	<12
V Lyrae		5.2	+29	30	11.0 *i*	RT Pegasi		59.8	+34	38	11.0 *i*
RS Lyrae		9.3	+33	15	13.5	T Pegasi	22	4.0	+12	3	8.8 *i*
S Lyrae		9.1	+25	50	13.0*d*	Y Pegasi		6.8	+13	52	<13.5
RU Lyrae		9.1	+41	8	12.5*d*	RS Pegasi		7.4	+14	4	14
U Draconis		9.9	+67	7	13.0*d*	X Aquarii		13.2	−21	24	10.8*d*
W Aquilae		10.0	− 7	13	10.0 *i*	RT Aquarii		17.7	−22	34	8.0
TZ Cygni		13.4	+50	0	9.5	T Lacertae		17.9	+33	52	9.5
U Lyrae		16.6	+37	42	10.8*d*	SL Lacertae		24.6	+39	48	11.5 *i*
T Sagittae		17.2	+17	28	9.0	R Lacertae		38.8	+41	51	9.5 *i*
TY Cygni		29.8	+28	6	12.5*d*	S Aquarii		51.8	−20	53	11.5*d*
RT Aquilae		33.3	+11	29	13.0*d*	RW Pegasi		59.2	+14	45	8.2 *i*
RV Aquilae		35.9	+ 9	42	12.8*d*	R Pegasi	23	1.6	+10	0	9.2*d*
R Cygni		34.1	+49	58	13.5	W Pegasi		14.8	+25	44	9.0 *i*
RT Cygni		40.8	+48	32	8.0 *i*	S Pegasi		15.5	+ 8	22	10.3*d*
TU Cygni		43.3	+48	49	9.0	R Aquarii		38.6	−15	50	10.3 *i*
X Aquilae		46.5	+ 4	12	9.0 *i*	Z Cassiop.		39.7	+56	2	14.2
χ Cygni		46.7	+32	40	10.0 *i*	Z Aquarii		47.1	−16	25	9.0 *i*
RR Aquilae		52.4	− 2	11	12.2 *i*	RR Cassiop.		50.6	+53	10	11.5
RS Aquilae		53.7	− 8	10	12.6*d*	V Ceti		52.8	− 9	31	12.0*d*
Z Cygni		58.6	+49	46	12.5*d*	R Cassiop.		53.3	+50	50	12.0*d*
S Cygni	20	3.4	+57	42	<13.5	Z Pegasi		55.0	+25	21	13.0*d*
R Capric.		5.7	−14	34	13.5	W Ceti		57.0	−15	14	9.0*d*
S Aquilae		7.0	+15	19	11.8	Y Cassiop.		58.2	+55	7	11.0 *i*
RU Aquilae		8.0	+12	42	11.2						

The letter *i* denotes that the light is increasing, the letter *d* that the light is

decreasing, the sign <, that the variable is fainter than the appended magnitude.

The magnitudes given have been compiled by Mr. Leon Campbell of the Harvard College Observatory, from observations made at the Vassar College, Whiteside, Swartz, and Harvard Observatories.

Maxima of Variable Stars of Short Period not of the Algol Type.

Unless otherwise indicated the times of maxima only are given; and the times of minima may be found by subtracting the interval printed in parentheses under the names of the stars.

RW Cassiop.	
d	h
(−5	19)
Feb. 3	2
17	22

RX Aurigae	
(−4	0)
Feb. 12	15
24	16

Y Aurigæ	
(−0	18)
Feb. 1	17
5	13
9	10
13	6
17	3
21	0
24	20
28	17

T Monocerotis	
(−7	23)
Feb. 22	6

W Geminorum	
(−2	22)
Feb. 5	6
13	3
21	1
28	23

ζ Geminorum	
(−5	0)
Feb. 9	7
19	10

V Carinæ	
(−2	4)
Feb. 4	2
10	19
17	11
24	4

T Velorum	
(−1	10)
Feb. 4	11
9	2

T Velorum	
d	h
Feb. 13	18
18	9
23	0
27	16

W Carinæ	
(−1	0)
Feb. 2	5
6	14
10	23
15	8
19	17
24	2
28	11

S Muscæ	
(−3	11)
Feb. 10	6
19	22

T Crucis	
(−2	2)
Feb. 6	12
13	5
19	23
26	16

R Crucis	
(−1	10)
Feb. 6	15
12	11
18	7
24	2

S Crucis	
(−1	12)
Feb. 4	1
8	18
13	10
18	3
22	19
27	12

W Virginis	
(−8	5)
6	5
23	12

V Centauri	
d	h
(−1	11)
Feb. 6	4
11	16
17	4
22	16
28	3

R Triang. Austr.	
(−1	0)
Feb. 4	5
7	14
11	0
14	9
17	18
21	4
24	13
27	22

S Triang. Austr.	
(−2	2)
Feb. 2	13
8	21
15	5
21	13
27	20

S Normæ	
(−4	10)
Feb. 6	21
16	15
26	9

RV Scorpii	
(−1	10)
Feb. 1	13
7	14
13	16
19	17
25	19

RV Ophiuchi Minimum	
Feb. 8	1
11	17
15	10

RV Ophiuchi Minimum	
d	h
Feb. 19	2
22	19
26	11

X Sagittae	
(−2	22)
Feb. 7	7
14	7
21	8
28	8

Y Ophiuchi	
(−6	5)
Feb. 7	3
24	6

W Sagittarii	
(−3	0)
Feb. 6	8
13	23
21	13

Y Sagittarii	
(−2	2)
Feb. 4	6
10	0
15	19
21	13
27	8

U Sagittarii	
(−2	23)
Feb. 5	19
12	13
19	7
26	1

β Lyrae	
{−3	2}
{−3	7}
Feb. 1	28
8	10
14	21
21	8
27	19

κ Pavonis	
(−4	7)
Feb. 4	11
13	13
22	15

U Aquilae	
d	h
(−2	4)
Feb. 1	14
8	14
15	15
22	15

XZ Cygni Period 11^h	
(−0	3)
Feb. 1	13
2	11
3	10
4	8
5	7
6	5
7	3
8	2
9	0
9	23
10	21
11	19
12	18
13	16
14	15
15	13
16	11
17	10
18	8
19	7
20	5
21	3
22	2
23	0
23	22
24	21
25	19
26	18
27	16
28	14

U Vulpeculae	
(−2	3)
Feb. 8	18
16	17
24	17

Minima of Variable Stars of the Algol Type.

[Given to the nearest hour in Greenwich Mean Time beginning with noon. To reduce to Central Standard time subtract 6 hours, or for Eastern time subtract 5 hours.]

U Cephei

	d	h
Feb.	3	1
	5	13
	8	1
	10	13
	13	1
	15	12
	18	0
	20	12
	23	0
	25	12
	27	23

Z Persei

	d	h
Feb.	1	7
	4	9
	7	10
	10	11
	13	13
	16	14
	19	15
	22	17
	25	18

RX Cephei

	d	h
Feb.	1	3

Algol

	d	h
Feb.	3	18
	6	15
	9	12
	12	9
	15	6
	18	3
	20	23
	23	20
	26	17

RT Persei

	d	h
Feb.	1	12
	2	9
	3	5
	4	1
	4	22
	5	18
	6	15
	7	11
	8	7
	9	4
	10	0
	10	21
	11	17
	12	13
	13	10
	14	6
	15	2
	15	23
	16	19
	17	16
	18	12
	19	8
	20	5

RT Persei

	d	h
Feb.	21	1
	21	22
	22	18
	23	14
	24	11
	25	7
	26	4
	27	0
	27	20
	28	17

λ Tauri

	d	h
Feb.	2	4
	6	3
	10	2
	14	0
	17	23
	21	22
	25	21

RW Tauri

	d	h
Feb.	1	20
	4	14
	7	9
	10	3
	12	22
	15	16
	18	11
	21	5
	23	23
	26	18

RW Persei

	d	h
Feb.	8	20
	22	1

RS Cephei

	d	h
Feb.	6	11
	18	21

RW Geminorum

	d	h
Feb.	2	5
	5	2
	7	23
	10	20
	13	16
	16	13
	19	10
	22	7
	25	3
	28	0

R Canis Maj.

	d	h
Feb.	1	9
	2	13
	3	16
	4	19
	5	22
	7	2
	8	5
	9	8
	10	12

R Canis Maj.

	d	h
Feb.	11	15
	12	18
	13	20
	14	1
	16	4
	17	7
	18	10
	19	14
	20	17
	21	20
	22	23
	24	3
	25	6
	26	9
	27	12
	28	16

Y Camelopardis

	d	h
Feb.	1	21
	5	4
	8	12
	11	19
	15	2
	18	10
	21	17
	25	0
	28	8

R Puppis

	d	h
Feb.	6	2
	12	12
	18	22
	25	9

V Puppis

	d	h
Feb.	1	17
	3	4
	4	15
	6	2
	7	13
	9	0
	10	11
	11	22
	13	9
	14	20
	16	6
	17	17
	19	4
	20	15
	22	2
	23	13
	25	0
	26	11
	27	22

X Carinæ

	d	h
Feb.	1	15
	2	17
	3	19
	4	21

X Carinæ

	d	h
	5	23
	7	1
	8	3
	9	5
	10	7
	11	9
	12	11
	13	13
	14	15
	15	17
	16	18
	17	20
	18	22
	20	0
	21	2
	22	4
	23	6
	24	8
	25	10
	26	12
	27	14
	28	16

S Cancri

	d	h
Feb.	1	3
	10	15
	20	2

S Velorum

	d	h
Feb.	1	5
	7	3
	13	1
	19	0
	24	22

U Urs. Maj.

Period 4^{h}

Feb. 1-12	13^{h}
13-28	14

RR Velorum

	d	h
Feb.	1	9
	3	6
	5	2
	6	23
	8	19
	10	16
	12	12
	14	9
	16	5
	18	2
	19	22
	21	19
	23	15
	25	12
	27	8

SS Carinae

	d	h
Feb.	2	15
	5	23
	9	6

SS Carinæ

	d	h
Feb.	12	13
	15	20
	19	4
	22	11
	25	18

Z Draconis

	d	h
Feb.	1	3
	2	12
	3	21
	5	5
	6	14
	7	22
	9	7
	10	15
	12	0
	13	9
	14	17
	16	2
	17	10
	18	19
	20	4
	21	12
	22	21
	24	5
	25	14
	26	22
	28	7

δ Libræ

	d	h
Feb.	1	20
	4	4
	6	12
	8	19
	11	3
	13	11
	15	19
	18	3
	20	11
	22	19
	25	2
	27	10

U Coronae

	d	h
Feb.	4	0
	7	11
	10	22
	14	9
	17	20
	21	6
	24	17
	28	4

R Arae

	d	h
Feb.	2	14
	7	0
	11	10
	15	20
	20	6
	24	17

Minima of Variable Stars of the Algol Type.—Continued.

U Ophiuchi

	d	h
Feb.	1	6
	2	2
	2	22
	3	18
	4	14
	5	10
	6	7
	7	3
	7	23
	8	19
	9	15
	10	11
	11	7
	12	4
	13	0
	13	20
	14	16
	15	12
	16	8
	17	4
	18	0
	18	21
	19	17
	20	13
	21	9
	22	5
	23	1
	23	21
	24	17
	25	14
	26	10
	27	6
	28	2
	28	22

Z Herculis

	d	h
Feb.	1	1
	3	4
	5	1
	7	3
	9	0
	11	3
	13	0
	15	3
	17	0
	19	3

Z Herculis

	d	h
Feb.	21	0
	23	3
	25	0
	27	3

RS Sagittarii

	d	h
Feb.	3	7
	5	17
	8	3
	10	13
	12	23
	15	9
	17	19
	20	5
	22	15
	25	1
	27	11

V Serpentis

	d	h
Feb.	3	17
	7	4
	10	14
	14	1
	17	12
	20	23
	24	10
	27	21

RX Herculis

	d	h
Feb.	1	19
	2	16
	3	14
	4	11
	5	8
	6	6
	7	3
	8	0
	8	22
	9	19
	10	16
	11	14
	12	11
	13	8
	14	6
	15	3
	16	0
	16	22
	17	19
	18	16

RX Herculis

	d	h
Feb.	19	14
	20	11
	21	8
	22	6
	23	3
	24	0
	24	22
	25	19
	26	16
	27	14
	28	11

SX Sagittarii

	d	h
Feb.	2	22
	5	0
	7	1
	9	3
	11	5
	13	7
	15	9
	17	11
	19	13
	21	14
	23	16
	25	18
	25	20

RR Draconis

	d	h
Feb.	2	21
	5	17
	8	13
	11	9
	14	5
	17	1
	19	21
	22	17
	25	13
	28	9

RV Lyræ

	d	h
Feb.	1	21
	5	11
	8	1
	12	16
	16	6
	19	20
	23	11
	27	1

U Sagittæ

	d	h
Feb.	3	12
	6	21
	10	6
	13	15
	17	0
	20	9
	23	19
	27	4

SY Cygni

	d	h
Feb.	4	19
	10	19
	16	20
	22	20
	28	20

WW Cygni

	d	h
Feb.	1	10
	4	18
	8	2
	11	9
	14	17
	18	0
	21	8
	24	16
	27	23

SW Cygni

	d	h
Feb.	1	13
	6	3
	10	16
	15	6
	19	20
	24	10
	20	23

VW Cygni

	d	h
Feb.	6	5
	14	15
	23	1

UW Cygni

	d	h
Feb.	2	7
	5	18
	9	4
	12	15
	16	2
	19	13
	23	0
	26	10

VV Cygni

	d	h
Feb.	1	20
	3	7
	4	19
	6	6
	7	17
	9	5
	11	17
	12	4
	14	15
	15	3
	16	14
	18	2
	19	13
	21	0
	22	12
	23	23
	25	11
	26	22
	28	10

RZ Cassiopeiae

	d	h
Feb.	1	18
	2	23
	4	4
	5	8
	6	13
	7	18
	8	22
	10	3
	11	8
	12	13
	13	17
	14	22
	16	3
	17	7
	18	12
	19	17
	20	21
	22	3
	23	7
	24	11
	25	16
	26	21
	28	1

Thirty-six New Variables.—In the H. C. O. Circular No. 122 Professor Pickering announces thirty-six new variables discovered by Miss Leavitt from an examination of six photographs, taken with a one-inch Cooke lens, of the region containing the nebula in Carina and the "Coal-sack". These plates cover a region of the sky about 30° square and show stars of the eleventh magnitude and brighter. In this entire region there are twenty-five stars whose variability was previously known and sixteen of these were rediscovered during the examination of the six plates. Professor Pickering thinks that the examination of ten good plates of any region, suitably arranged as to time may be considered as thorough, although no examination can be exhaustive. All but one of the new variables are brighter than the tenth magnitude at maximum and one is as

bright as 7.0. Six of them are probably of the Algol type and twelve others are of short period. Their positions will be given in our next number.

The positions and observed range of brightness of the new variables is given in the following table. We have been obliged to omit the Harvard numbers because of the narrow width of our page. The first is numbered 1269 and the last 1304.

NEW VARIABLE STARS.

Constellation	C. P. D. No.	R. A. 1900			Dec 1900.		Bright.	Faint	Range.
		h	m	s	°	′			
Carina	. . . .	9	26	29	−73	6.3	9.0	<10.0	1.0
Carina	−59° 2007	10	12	30	59	42.9	9.2	10.3	1.1
Carina	59 2059	10	16	56	59	57.0	9.8	10.5	0.7
Carina	59 2135	10	23	14	59	9.7	9.4	10.3	0.9
Carina	56 3425	10	25	26	57	6.2	8.0	9.0	1.0
Carina	61 1705	10	28	30	61	16.1	8.8	9.8	1.0
Vela	55 3800	10	40	54	55	45.8	8.4	9.4	1.0
Carina	61 1955	10	50	12	61	30.5	9.0	9.7	0.7
Carina	64 1564	10	53	22	64	35.9	9.0	10.0	1.0
Carina	63 1798	10	58	19	63	43.4	9.3	10.0	0.7
Carina	60 2497	11	0	7	60	26.3	8.8	9.6	0.8
Carina	58 3216	11	5	23	58	17.8	7.	8.	1.
Centaurus	51 3909	11	5	29	21	56.9	9.8	10.7	0.9
Centaurus	47 4810	11	6	34	47	18.0	8.7	9.6	0.9
Centaurus	50 4289	11	26	31	50	53.2	9.2	10.2	1.0
Centaurus	47 5118	11	34	57	47	24.5	9.1	10.0	0.9
Centaurus	. . . .	11	36	10	57	6.3	9.8	13.0	3.2
Centaurus	62 2223	11	36	14	62	8.4	8.7	9.5	0.8
Musca	66 1637	11	39	49	66	45.0	8.7	9.7	1.0
Centaurus	. . . .	11	41	42	61	20.2	10.6	<11.4	0.8
Centaurus	59 3809	11	43	5	60	0.5	8.8	9.8	1.0
Musca	64 1725	11	47	24	64	50.8	9.4	10.3	0.9
Centaurus	53 4824	11	49	8	53	36.7	9.8	10.5	0.7
Crux	58 4151	12	6	42	58	13.6	8.7	9.3	0.6
Centaurus	49 4965	12	7	51	49	39.0	9.1	10.0	0.9
Centaurus	49 5046	12	12	30	49	10.8	8.8	11.4	2.6
Centaurus	48 4730	12	15	52	48	39.3	8.3	10.2	1.9
Crux	59 4388	12	35	41	59	14.7	8.5	9.4	0.9
Centaurus	53 5293	12	37	37	53	58.8	9.4	<11.0	1.6
Crux	58 4490	12	40	32	58	34.6	8.5	9.0	0.5
Centaurus	59 4781	13	3	10	59	42.9	9.4	10.5	1.1
Centaurus	. . . .	13	27	6	63	32.4	9.5	10.5	1.0
Centaurus	56 5865	13	33	45	57	6.4	7.6	8.7	1.1
Centaurus	61 3912	13	35	3	61	15.8	9.8	10.8	1.0
Centaurus	57 6324	13	43	50	58	0.3	8.0	8.9	0.9
Centaurus	−59 5228	14	44	21	−59	54.7	9.7	10.7	1.0

Definitive Elements of RR Geminorum.—In *A.N.* 4132 Mr. K. Graff gives new elements of this variable depending upon maxima and minima observed in the years 1903-1906:

Maxima = J. D. 2416223.286 Gr. M. T. + $0^d.3972927$ E.

The period is thus $9^h\ 32^m\ 06^s.09$. The star is of the δ Cephei type, the minimum occurring $1^h\ 33^m$ before the maximum. The range of magnitude is from 9.9 to 10.6.

Radial Motion of RZ Cassiopeiæ.—In *A. N.* 4135 Mr. J. Hartmann gives measures of the radial velocity of this Algol-type variable from two spectrograms taken, the one a quarter of the period before a minimum and the other about the same interval after a minimum. The first gives V = + 33.1 km. and the second gives V = − 111.9 km. thus verifying the supposition of a dark

eclipsing body, and indicating that the bright component is about 1170000 km. distant from the focus of its orbit.

Observations of Variable Stars by Sigurd Enebo.—A neatly printed pamphlet of 50 pages has just come to hand containing the observations of variable stars by Mr. Sigurd Enebo, of Dombaas, Norway, in the years 1903-6. Dombaas is in longitude 9° 7′ east from Greenwich and latitude 62° 05′ north. Mr. Enebo gives an extensive series of observations of fourteen stars, viz. X Persei RR Cygni, ϵ Aurigae, ρ Cassiopeiæ, U Lacertæ, SV Cygni, u Hercules, 32 Vulpeculae, B. D. + 33° 4056, B. D. + 49°, 3239, B. D. 45° 3271, 76.1905 Cygni, 29.1906 Persei and 40.1906 Geminorum. In four of these 32 Vulpeculæ, B. D. +33° 4056, B. D. + 49° 3239 and B. D. 45° 3271 this variation was not verified.

New Variable 122.1906 Ceti. In *A. N.* 4131 Mr. Egon R.v. Oppolzer of Innsbruck calls attention to the star BD +0°.249, the position of which for 1855 is R. A. $1^h\ 24^m\ 39^s.4$, Dec. +0° 35′.3. The magnitude in the B. D. is 9.3, but upon a series of thirteen photographic plates exposed 30^m each on the nights of Oct. 11, 13, and 17, 1906 Mr. Oppolzer finds a rapid variation in the brightness of this star on each night. From an inspection of the resulting magnitudes from the different photographs it is impossible to determine the period or the character of the light variation. The amplitude of variation noted is from magnitude 8.3 to 9.0 but the time of minimum was not covered by the photographs. Apparently the star was near maximum Oct. 11.388, 13.583 and 17.455.

GENERAL NOTES.

The promised aid from various sources for the fifteenth volume of this publication is encouraging.

The photographic studies of the dark patches in the Galaxy, presented in the last issue of this publication, by E. E. Barnard of Yerkes Observatory opens a line of mature thinking well worth the attention of scholars able to deal with it successfully. When we looked at the original negatives taken on Mount Wilson with his new Bruce photographic instrument, we very much desired to try the printing of these splendid views from half-tones made with screens carrying 200 lines to the inch. Only those who have had experience in handling this kind of art work know how delicate and difficult a job it is to do it well, and so we did not wonder that Mr. Barnard hesitated to give his consent to have finest astronomical work put on a printing press in a country town of less than 4000 inhabitants. But the trial was made, and, judging from a kind and appreciative personal letter received from Mr. Barnard later, we were glad to know that the work pleased him. The fine new half-tone press, owned by another person, but in connection with our own office makes it possible for us to do fine printing equal to that usually done only in large cities.

The frontispiece to this number is the reproduction of a photograph illustrating the new method by which Joel H. Metcalf of Taunton, Mass., is very successful in discovering new asteroids. Below we give his statement descriptive of the method:—

The plate is one exposed for asteroids taken according to the method described in *The Astrophysical Journal* Vol. XXIII. No. 4, May 1906. There are two exposures of 35 minutes each on the plate. As the mean motion of the asteroids and not the stars was followed the stars trail. Between exposures the plate was shifted 25″ of arc in Right Ascension. The comet is nearly in the middle of the picture. J. H. M.

Lantern Slides of Celestial Objects. In the advertisements of each issue of this publication will be found a long list of lantern slides which are useful for lectures. These slides are called for from all parts of the United States. A large order is now being filled for an interested party in India.

Mira at Maximum. The maximum of Mira (*o* Ceti) this winter has been unusually bright, the star being for several days brighter than α Ceti and equalling β Ceti and α Arietis. This affords an unusual opportunity for the study of the peculiar spectrum of a variable star of long period.

The Astronomical Society of Mexico has recently conferred its annual medals upon the following astronomers, William R. Brooks of Geneva, New York, M. Giacobini of the Nice Observatory, France, August Kopff of Heidelberg, Germany, Jesùs Medina of the Popular Observatory of the Astronomical Society of Mexico.

Leonids at University of Virginia. The Leonids were observed here on November 16, which was the only partly clear night during the continuance of the shower. The display was much stronger than has usually been observed here on November 15, which is a day nearer the maximum. This would seem to show that the display this year was quite a strong one. The following table gives the distribution of the meteors with regard to time.

Time		Leonids	Others	Total	Remarks
	$-12^h\ 0^m$	1	7	8	Clear, Leo just rising hidden by trees.
$12^m\ 0^h$	$-13\ 0$	4	10	14	Clear, Leo still partly hidden by trees.
$13\ 0$	$-14\ 0$	9	8	17	Clear.
$14\ 0$	$-14\ 11$	3	1	4	Clear.
$14\ 36$	$-15\ 0$	3	3	6	Clear.
$15\ 0$	$-16\ 0$	14	12	26	Clear.
$16\ 0$	$-17\ 0$	14	10	24	Clouds near horizon, increasing after $16^h.5$.
$17\ 0$	$-17\ 21$	4	2	6	Part cloudy.
		52	53	105	

Most of the Leonids are fairly bright, there being eight as the first magnitude. The prevailing color was yellow, but there were many green and a few red ones. The finest meteor I have ever observed came at $17^h\ 51^m$. It was a Leonid, green in color, went only 3° in about $1^s.2$, and gave as much light as the Moon at quarter. It ended at ψ Virginis and appeared to be about 15′ in diameter. From twelve meteors plotted near it, the radiant point of the Leonids was found to be at α 151°, δ +22°, the figures being given only to the nearest degree. The trains left by some of the meteors were very persistent, and the display was very good considering that it was two days past maximum. Several minor radiants were in strong activity.

CHAS. P. OLIVIER.

Leander McCormick Observatory.

Potsdam Photometric Durchmusterung. Volume XVI of the *Publications of the Astrophysical Observatory* at Potsdam recently issued has been received at Goodsell Observatory.

A pretty full review of this interesting Publication has already appeared in several American scientific publications, so that our readers are probably already informed of the leading points of interest regarding this new volume. In some respects, we have found that written by Solon I. Bailey in *Science* of November 2,

as useful as any we have seen. After explaining the methods of work at Potsdam, Oxford and Harvard Mr. Bailey makes a comparison between the work of these three in the following language which forms the closing part of his article:

The Harvard values used are those of volumes XIV and XXIV. These are referred to as Pickering I. and Pickering II. Later volumes of the Harvard photometry will be discussed at another time. Tables are given showing the systematic mean differences, Potsdam—PI., Potsdam—PII. and Potsdam—Pr (Oxford), for the zone in question, and a special table giving the individual cases in which the differences amount to half a magnitude, or more. The number of such cases is small, one for PI. and five for PII. and Pr. This number is less than in preceding parts of the work, which is explained by the authors as due to the fact that both at Harvard and at Oxford the pole-star was the standard of comparison, and that errors would naturally be fewer in this zone, 60° —90°, which lies near the pole-star.

These tables are followed by others giving the results for all four zones, compared. Since the systematic differences are practicaly the same for all four zones an inspection of the final means will be sufficient. These differences can best be shown by the following brief table.

	Potsdam—B D.	Potsdam—P I.	Potsdam—P II.	Potsdam—Pr.	Means
White	+0 25	+0.29	+0.29	+0.23	+0.26
Yellow white	+0.26	+0.25	+0.21	+0.20	+0.23
White yellow	+0.11	+0.09	+0.02	+0.06	+0.07
Yellow, etc	−0.05	−0.04	−0.09	−0.07	−0.06

The most striking feature shown in this table is the remarkable accordance in the mean results at Bonn, Harvard and Oxford. In each case there is a positive difference of about a quarter of a magnitude for white stars, and this quantity diminishes systematically to a small negative value for the yellow-red red stars. The systematic differences between the Bonn, Harvard and Oxford catalogues are inappreciable. In all cases Potsdam makes the white stars fainter and the red stars brighter than the other three observatories. Between these two extremes, however, somewhere between the whitish-yellow and yellow stars, the differences disappear. The differences seem difficult of explanation. On the other hand, we have Potsdam with two observers and with Zöllner photometers, and on the other hand, Bonn, Harvard and Oxford, with eight observers and photometers of several kinds. The differences concerned are small, however, and it may well be regarded as remarkable that the color scale of the different catalogues should agree so closely that for stars of one color the differences are positive, and for those of another color, negative.

Another relation is shown by arranging the observations with regard to magnitude. We may use for illustration Potsdam—P I. It is thus found that the scale of magnitude of the Harvard photometry lies, for stars of different colors, on both sides of that of the Potsdam scale. For white stars a full Harvard magnitude equals about 1.05 of the Potsdam scale; for yellowish-white, 1.03; for whitish-yellow, 1.01; and for yellow and red stars, 0.94; and for all about 1.00. Taking into consideration the systematic differences which are found in the results of a single observatory by different observers and instruments, as

shown in the present discussion for Potsdam, and also the known influence of the Purkinje phenomenon, the differences of scale between Potsdam and Harvard are surprisingly small.

A Century of Progress in Astronomy is the title of a new book by Hector Macpherson, Jr., who is a member of the Astronomical Society of France and the Astronomical Society of Belgium and the author of Astronomers of Today. The publishers of this book are William Blackwood and Sons, Edinburgh and London. It can also be obtained by readers in this country through any leading book seller even in our smaller cities.

The book consists of 246 pages and is put in this small compass to give a brief compact record of the wonderful progress in astronomy for the past hundred years for popular readers who do not care for details of study or discovery, but simply want to know the facts about astronomy that have come into recent knowledge that a busy person can learn and ought to know even if he has not much time to give to such things. For this reason, we suppose, the author has omitted all illustrations and given himself simply, directly and earnestly to the task of writing plainly and easily about the very interesting themes of astronomy that these recent years brought to light.

In reading this book, those acquainted with that which is new in recent astronomy will readily see that the author has drawn on and faithfully acknowledged the help received from the best scholars and writers of the period of of which he speaks; notably Professors Schiaparelli, Newcomb, Lowell, Young, Sir Robert Ball, Messrs. Gore, and Flamarion, and Miss Clerke and some others all of whom are authorities who hold high place in modern astronomical science.

When readers of this magazine come to chapters II and XII that treat of the construction and the extent of the universe, they will recognize that they have seen parts of these chapters in articles which the author has previously contributed to POPULAR ASTRONOMY.

Our readers will be interested in the plan of this new book, by a running glance at its chapters in order. The first gives an account of the influence of Herschel's work, his characteristics, early life, removal to England, assistance of Caroline Herschel, discovery of the planet Uranus, position as King's astronomer, his latter years and his and his sister's death.

The next chapter considers Herschel as a discoverer: how he advanced astronomy by observing the Sun and the planets including satellites, comets, motion of the solar system in space, the discovery of binary stars, clusters, nebulæ and nebulous stars. His thinking on the nebular hypothesis, his star-gauging, disk-theory, subordinate clusters, abandonment of the disk-theory, second method of star-gauging and then follows an estimate of the value of Herschel's work, in strong, yet deservedly fair outline that makes us remember Miss Clerke's unique measure of this wonderful man when she says "One can not reflect without amazement that the special life-task set himself by this struggling musician—originally a penniless deserter from the Hanoverian Guard—was nothing less than to search out the construction of the heavens.

The third chapter is an interesting survey of the progress of our knowledge of the Sun by many scholars since the time of Schwabe. The review includes the researches of Wolf, Lamont, Sabin, Gautier, observations of Carrington and Sporier, Fraunhofer, Kirchoff, Janssen, Lockyer, Huggins, Zollner, Young, Secchi, Respighi, and Tacchini.

The themes considered are; sun-spot period, the reversing layer, corona, chromosphere, photosphere, faculae, solar photography, and spectroscopy, magnetism

and solar theories. Prominent persons now at work in observation, photography, theory and atlas-making are Hale, Maunder, Poor, and others doing good work who call themselves amateurs.

The fourth chapter deals with the Moon, beginning with the life and work of Shröter and continuing with that of Mädler and of Schmidt. Other themes are the changes on the Moon, selenography, in England, lunar atmosphere, lunar photography, work of William H. Pickering, the new selenography the Moon's heat, motion of the Moon, acceleration of the Moon's mean motion and the work of Laplace, Adams and Delaunay. In connection with lunar photography the author might have spoken of the splendid work in photographing the lunar surface on a large scale, which for some time has been in progress at the Paris Observatory. The thorough study of the photographs promises much when the work is properly advanced.

In a similar way the author considers the minor planets in chapter five, the outer planets in six, comets in seven, meteors in eight, the stars in nine, the light of the stars in ten, stellar systems and nebulæ in eleven, stellar distribution and the structure of the universe in twelve, and, in the last, stellar evolution.

In the last chapter we did not notice that reference was made to the new theory of evolution recently suggested by Chamberlin and Moulton of the University of Chicago. This theory is only in its preliminary form, and on this account probably should yet be held in the background, although its future promise has scientific value.

The author and publishers have done good work in bringing out this new book, for it is planned to meet a large and real demand in the minds of general scholars and readers who want the main facts of science, stated in plain languages that they may get them quickly and as easily as precious time will allow.

Lunar and Hawaiian Physical Features Compared. Professor William H. Pickering of Harvard College Observatory, Cambridge, Mass., has just published an interesting quarto volume, bound in stiff covers, with over 50 drawings and fine half-tone illustrations on a comparison of some of the physical features of the Moon and of Hawaii.

In order to do this work most thoroughly, in 1905 Professor Pickering visited the Hawaiian Islands, and studied the crater formations in various places minutely, for the purpose of comparing certain classes of them with those of the Moon which are best known to astronomers at the present time. In this paper Professor Pickering has gone into the details of the comparison very fully and the illustrations bear out well the points of similarity and of dissimilarity referred to in the descriptive text.

He certainly is the better qualified for such a piece of work as this from the fact that he has given special study to the surface markings of the Moon, for years' under very exceptionally favoring circumstances. His lunar photography and the painstaking study of lunar details is widely and well-known to all students of modern astronomy who read the current publications of the day.

"The lunar surface presents such a strong contrast to the more thickly populated portions of the Earth, that little resemblance between them can be traced. It has therefore naturally proved very difficult to explain the nature and origin of many of the features of our satellite. Even those of our volcanic regions which have been most extensively studied, show little analogy to the Moon. There are other regions however, notably in the Hawaiian Islands, where an entirely different class of volcanic phenomena are exhibited. These it is now found bear a striking resemblance in some respects to what we find on our satellite. Although

the Hawaiian craters are mostly extinct, or at present inactive, yet they are the only ones known of this type exhibiting any activity at all.

In Hawaii a considerable number of the craters are of the engulfment type, as distinguished from the explosive type so well developed in Southern Europe. In the latter class a high truncated cone is built up by mild eruptions of steam and cinders, sometimes alternating with lava. At long intervals violent explosions occur, which sometimes blow away large portions of the summit thus entirely changing the shape of the mountain; nothing whatever of this sort is found on the Moon. In volcanoes of the engulfment type, on the other hand comparatively little steam is evolved, often there is no exterior cone, and the craters enlarge quietly by the cracking off and falling in of their walls."

Professor Pickering also includes in this book the results of special study he has made of Eratosthenes. He devoted the summer of 1904 to work on this subject, having gone for that purpose to the Lowe Observatory, Echo Mountain, California. His observations of the fine cracks which seam its interior showed that as the Sun rose these cracks broadened into so-called "canals": Professor Pickering thinks these cracks give out water-vapor which produces enough vegetation along their sides to make these canals.

In comparing them with the Martian canals they appear to be much smaller remembering that one on Mars reaches the enormous length of 3,500 miles. If they are produced naturally the surface of the planet must be cracked in many places.

It is generally thought that terrestrial volcanoes lie along subterranean cracks that do not reach the surface. The volcanoes of the great chain of the Andes lie along a straight crack reaching from southern Peru to Terra del Fuego, 2500 miles in length. The volcanoes of the Aleutian Islands lie along a curved crack equally long. Since other shorter lines of volcanoes are very numerous upon the Earth, and since countless others existed in former times, the cracks in the Earth's crust must be exceedingly numerous. Every dike and mineral vein indeed bears witness to this fact. There is no reason why terrestrial cracks should not be as numerous as those upon the Moon. In the case of the Earth they have usually been closed sometimes by liquid matter from below, and sometimes by surface denudation. There is one crack, however, which comes to the surface in various places in eastern Asia and western Africa, and stretching from the Dead Sea to Lake Nyassa, reaches the enormous length of 3500 miles. The longest known crack upon the Moon, that of Sirsalis, measures about 400 miles.

It does not necessarily follow, however, even if both the Martian and lunar canals are due to vegetation, that the vegetation, is watered in the same manner.

We have been interested to examine closely the half-tone plates presented in this volume, because of their perfect and attractive appearance. By the use of the magnifying glass those half-tones show a marvellously clean, even and exact finish which we have scarcely ever seen equalled for the number of lines used to the inch. With such a foundation the art printer with fine ink can do his part well. Professor Pickering ought to feel proud of such work to accompany his text.

Readers interested in this paper need to peruse it to get the full meaning and effect of it because of the amount of detail it contains all of which bears on the one important point of likeness between certain surface features of the Earth and that of the Moon. More and more must the conclusion be strengthened that the surface markings of the Moon are very largely those of volcanic origin from such evidences as these furnished by Professor Pickering.

Association for the Advancement of Science begin its meeting in New York City Decembr 14, and will be probably one of unusual interest and importance. The list of subjects to be considered is very general and covers a range of science well represented by the varied associations now working together under this one name. We notice that it is a question of some interest whether or not it is the wisest course to have all these different departments of scientific work scheduled for hearing at the same time and place. It is probable that light on this question will soon be found.

Star Charts. During the last three years we have been publishing a little pamphlet called star charts of the constellations for the aid of teachers of astronomy. Some state Universities are using very many of these charts.

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The building and equipping of new observatories, the manufacture, sale or purchase of new astronomical instruments, with special reference to improvements and new designs, and the results of new methods of work in popular language, will be deemed very important matter and will receive prompt attention. It is greatly desired that all persons interested bear us in mind and promptly respond to these requests.

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